

ASTRONOMY

OCTOBER 1977

\$1.50



NEW FROM



Actual Size 17 x 22

Jupiter From Io

This dramatic painting reveals an incredible vista that man may never witness first hand: the incredible bulk of Jupiter looming over the surface of its satellite Io. Located deep within Jupiter's intense magnetic field, Io is one of the most lethal places in the entire solar system. To view this scene, we must rely on the imagination of artist John Clark.

To you, our readers, ASTRONOMY now offers a series of 8 dynamic, new, full color Art Reprints of some of the best paintings — by artists John Clark, Victor Costanzo, James Hervat, Mark Paternostro, Adolf Schaller and Rick Sternbach — that have appeared in ASTRONOMY Magazine.

Adding to the drama, depth and realism of each piece, these Art Reprints are printed on 80 lb. linen finish paper, and are coated with a high gloss varnish. And each reprint is surrounded with a one inch white border,



Actual Size 17 x 22

Black Hole

A nearly invisible small black hole speeds through a dense interstellar cloud of gas and dust, leaving behind a trail of gravitationally disturbed material. The infalling material becomes hot and emits light as it drains out of the known universe. Artist Mark Paternostro speculates on the appearance of these still undetected objects.



Actual Size: 17 x 22

The Galactic Core

The nucleus of our galaxy is one of the true unknowns in our universe. Recent radio and infrared observations suggest that two titanic swirling rings of gas and dust occupy the core of our galaxy. These rings were apparently produced by an explosion 10 million years ago. Victor Costanzo's painting indicates that actual conditions at the galaxy's center remain a mystery.



Actual Size 17 x 22

Colony in Space

What will space stations and orbiting colonies of the future look like? Artist Rick Sternbach provides an ingenious answer in his painting of a mile wide space station wheeling slowly above the gibbous Earth. Shuttle rockets near the station's hub bring ore from the lunar surface for refinement in the station's zero gravity manufacturing center.

Pluto

The setting sun glints off a low plain of methane ice on the surface of the smallest and most distant planet, Pluto. The cold and forbidding scene — completely alien to Earth dwellers — comes to life in this rendition by James Hervat. The mysteries of Pluto are brought home to us as we stand and gaze back toward our incredibly distant sun.



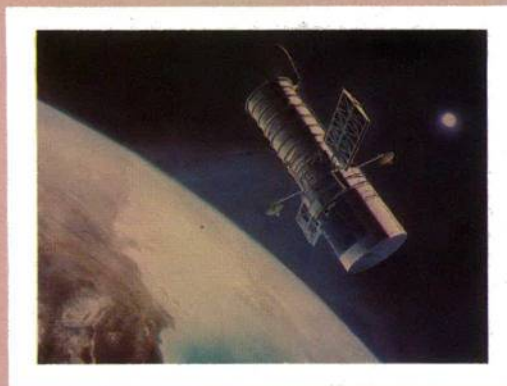
Actual Size 17 x 22

ASTRONOMY

making it easier to frame, or suitable for hanging as is.

These magnificent, colorful Art Reprints are available for only \$2.00 each, plus \$1.00 per order for shipping and handling. Or if you prefer, by ordering a full set of 8 Art Reprints, you can take advantage of our special price of \$12.75 for a set of 8 — that's a 20% savings!! — plus \$1.00 per order for shipping and handling.

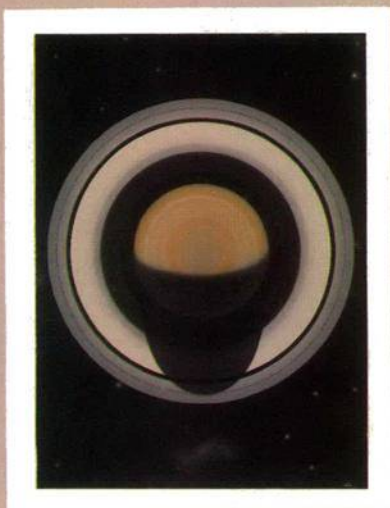
So don't wait . . . Order your ASTRONOMY Art Reprints today!



Actual Size: 17" x 22"

Space Telescope

Painted by John Clark from official NASA blueprints, this poster depicts the Space Telescope — a powerful 94 inch (2.4 meter) aperture telescope due to be launched during the early 1980s by NASA's Space Shuttle. This is an accurate depiction of an instrument that will revolutionize man's view of the universe during the decades it remains in operation.



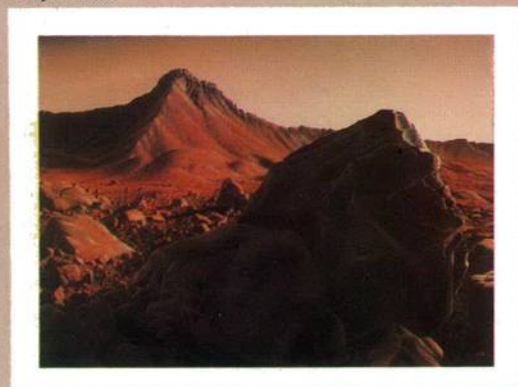
Actual Size: 17" x 22"

Saturn

In an unusual perspective from above the north pole of Saturn, we can identify the planet's three main rings and their sizes relative to Saturn itself, enabling us to grasp the vast extent of Saturn's ring system. This remarkable painting by Adolf Schaller gives us a view of the planet not obtainable from Earth.

Vallis Marineris

Photographs returned from Mariner and Viking probes revealed for the first time the immensity of Vallis Marineris, the equatorial canyon of Mars. This painting by Adolf Schaller — meticulously transcribed from overhead Viking photos — takes us to the foot of a blanket of landslide rubble in the canyon itself.



Actual Size: 17" x 22"

Quantity	Item	Price	Total
	Jupiter From Io	@ 2.00	\$
	Black Hole	@ 2.00	\$
	Colony in Space	@ 2.00	\$
	The Galactic Core	@ 2.00	\$
	Pluto	@ 2.00	\$
	Saturn	@ 2.00	\$
	Vallis Marineris	@ 2.00	\$
	Space Telescope	@ 2.00	\$
	Full Set of 8 Art Reprints (one of each of the above)	@ \$12.75	\$

PLUS SHIPPING, HANDLING PER ORDER \$1.00

Sorry — Art Reprints may not be billed.

Send check or money order to:
ASTRONOMY
411 E. Mason St., 6th Floor
Milwaukee, WI 53202

**TOTAL
AMOUNT** \$

Date: _____

Name _____
(please print)

Address _____

City _____ State/Prov. _____ Zip _____

(We will start shipping ASTRONOMY Art Reprints on Friday, July 15, 1977.)

SPACE 1978

A new art reprint calendar from ASTRONOMY

ASTRONOMY magazine proudly presents SPACE 1978 — an exciting new art and photography calendar depicting the awesome beauty of space and astronomy in vivid breathtaking color.

SPACE 1978 features a collection of full color varnished reproductions of some of the best cosmic art and photographs that have appeared in ASTRONOMY . . . and each is

accompanied by a short, easy-to-understand description! From the ruddy glow of interstellar gas clouds and raw energy pouring from mysterious black holes and quasars . . .

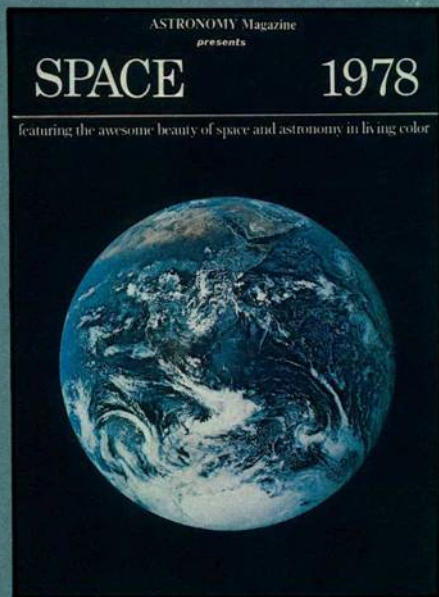
to the exploration of distant planets and the sheer beauty of the star-filled sky . . . the colorful, pictorial universe is displayed in a format that "begs" that the subjects be framed.

Printed on coated 80 lb. paper and varnished, SPACE 1978 is spiral bound and "hole punched" for convenient hanging. Each reproduction is surrounded by a narrow white border for greater ease in framing . . . and complete framing instructions are provided!

Hallmarks of ASTRONOMY's quality and beauty epitomize this distinctive calendar — whether the illustrations are framed immediately, or the calendar hung and used throughout the year.

Exciting Features Include:

- Full color, varnished art & photos
- Framing instructions provided
- Punched for hanging
- Planet oppositions & special sky events noted
- Room to jot birthdays & other appointments
- 1978 Calendar



Size: 8-3/4" x 11-3/4"

SPACE 1978 is a timeless gift.

Order now for the 1977 holiday season.

only \$4.50 each

(Include 75¢ per order for shipping & handling.)

ASTRONOMY

411 E. Mason St., 6th Floor
Milwaukee, WI 53202

Please send me _____ copies of ASTRONOMY's SPACE 1978.

Enclosed is _____ (including 75¢ for shipping and handling).

Send check or money order to:

ASTRONOMY
411 E. Mason St., 6th Floor
Milwaukee, WI 53202

Date: _____

Name _____
(Please Print)

Address _____

City _____ State/Prov. _____ Zip _____

We will start shipping orders for SPACE 1978 on Monday, Oct. 17, 1977.

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

October 1977

Vol. 5, No. 10

PUBLISHER and EDITORIAL DIRECTOR

Stephen A. Walther

EDITORIAL

Managing Editor and
Assistant Editorial Director

Penny Oldenburger

Technical Editor

Richard Berry

Associate Editor

Henry J. Phillips

Staff Writer and

Astro-News Editor

Mary Jane Lamers

Contributing Editors

James Mullaney

James E. Oberg

Contributing Photographers

Bob Provin

Brad Wallis

GRAPHICS

Production Manager

David A. Schwartz

Staff Artist

Mark Paternostro

CIRCULATION

Subscriber Relations

Jodi Groth

Rosemary L. Pickart

COMMUNICATION

Information Officer

Penny Oldenburger

- 6 MAN FINDS A NEW WORLD: MARS
- 10 THE POLAR REGIONS OF MARS
by James Cutts
- 18 MARTIAN CLIMATE: PAST, PRESENT and FUTURE
by John Gribbin
- 28 STELLAR FRONTIERS
Rich Clusters of Galaxies
by Wallace H. Tucker
- 34 SKY ALMANAC
U.S. Gets Partial Eclipse
- 36 PLANET FINDER — OCTOBER 1977
- 42 EQUIPMENT ATLAS
1977 Buyers' Guide to Small Telescopes
- 52 GAZER'S GAZETTE
"Stoplight" Stars: The Red Variables
by Thomas C. Brett
- 57 ASTRONOMY REVIEWS
- 60 ASTRO-MART
- 64 GUIDE TO BACK ISSUES
- 65 ASTRO-NEWS
- 73 OCTOBER STAR DOME
by James Mullaney and Henry J. Phillips
- 75 Close-Up on the Pegasus Region

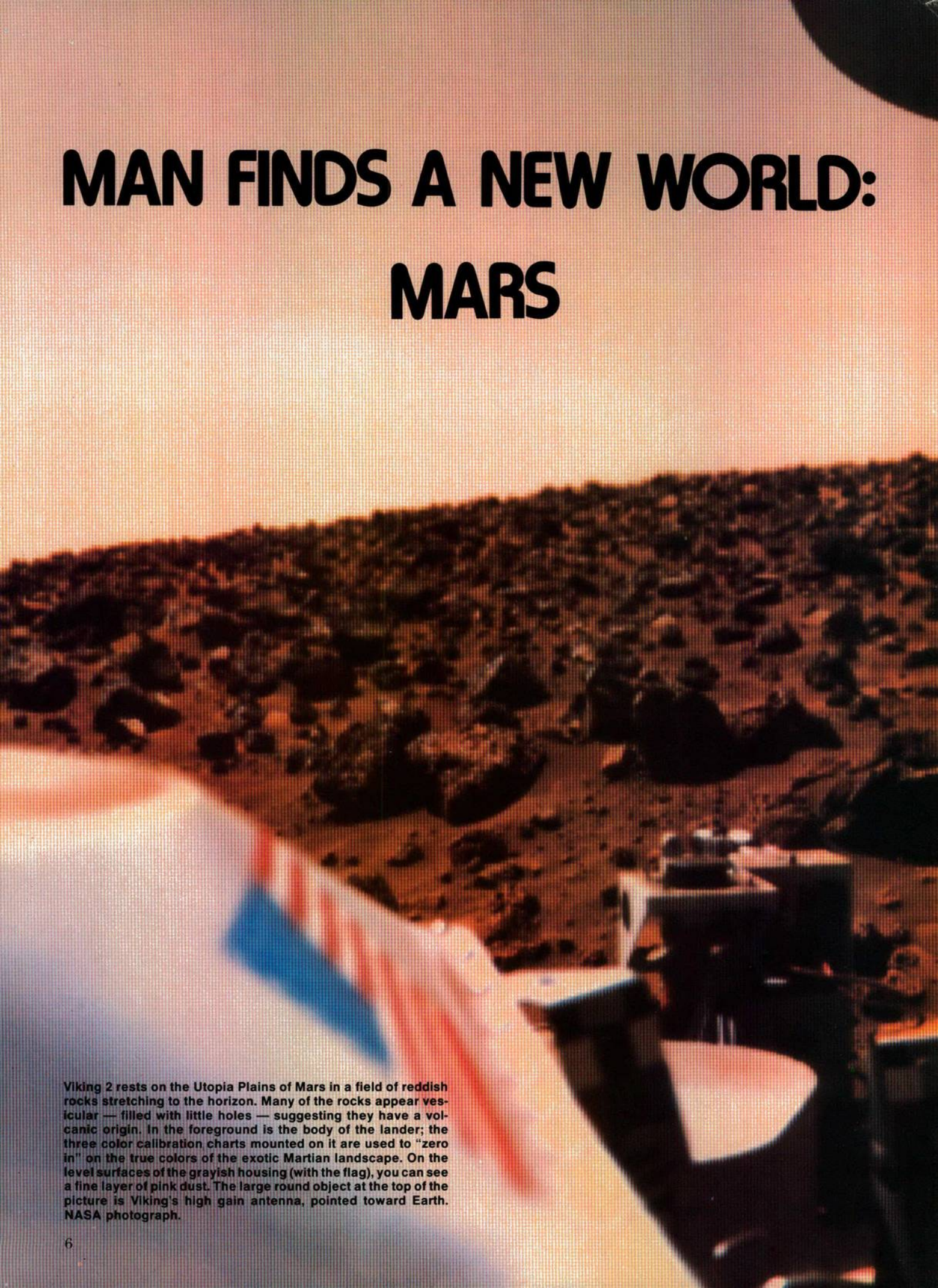


Cover

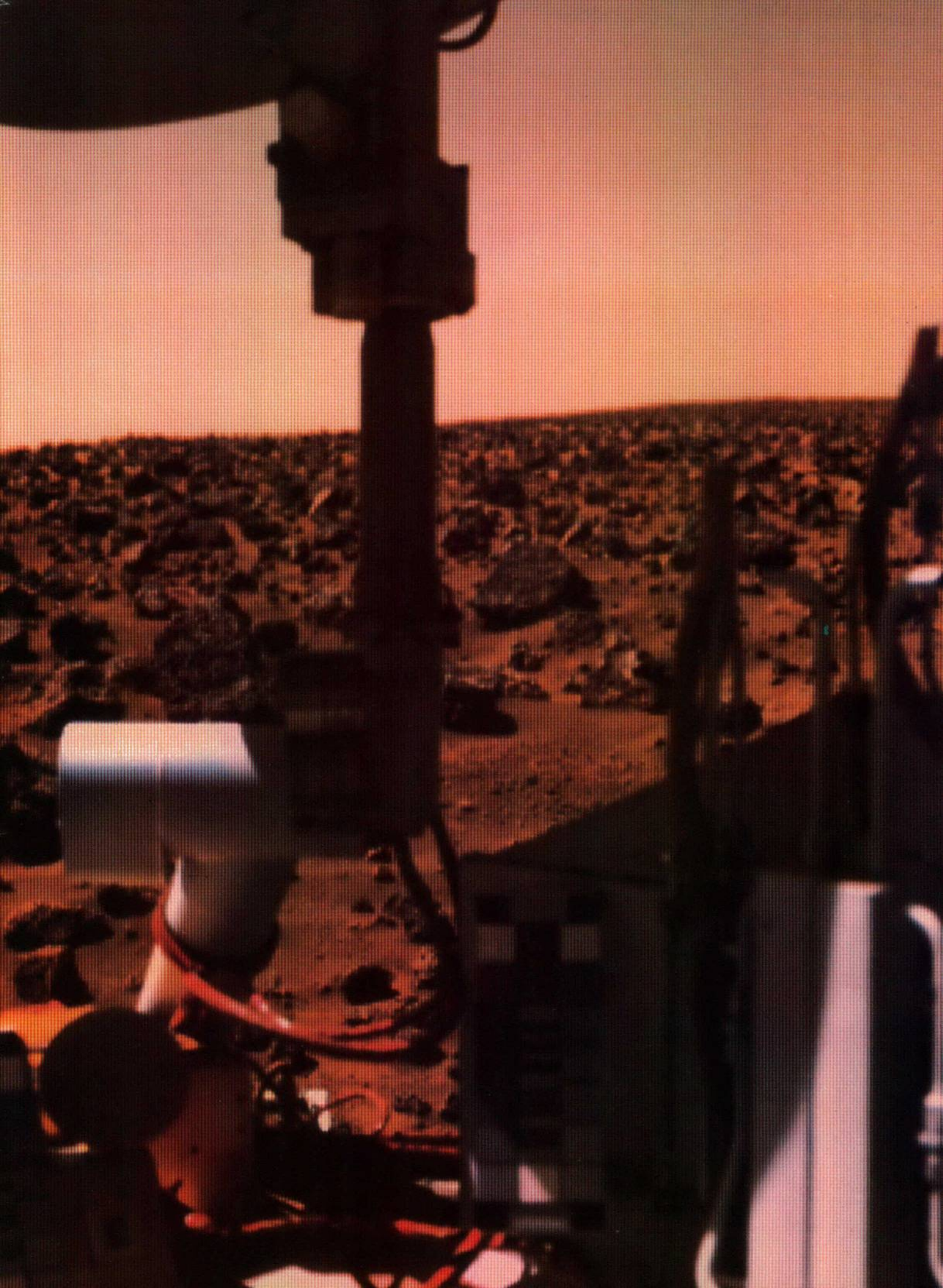
Blue beams of ultrarelativistic protons pour out from the center of a black hole. The beams explain why radio galaxies appear to have radio sources on either side of them. Beams pour out of an electric field which is created by the black hole and measures several hundred astronomical units in diameter. In this issue, **ASTRONOMY** explores a variety of topics, ranging from the Martian climate and polar caps to a buyer's guide for telescopes. This month's **Stellar Frontiers** describes how galaxies cluster, and **Gazer's Gazette** shows you how easy it is to observe long-period variables. Artwork by Adolf Schaller.

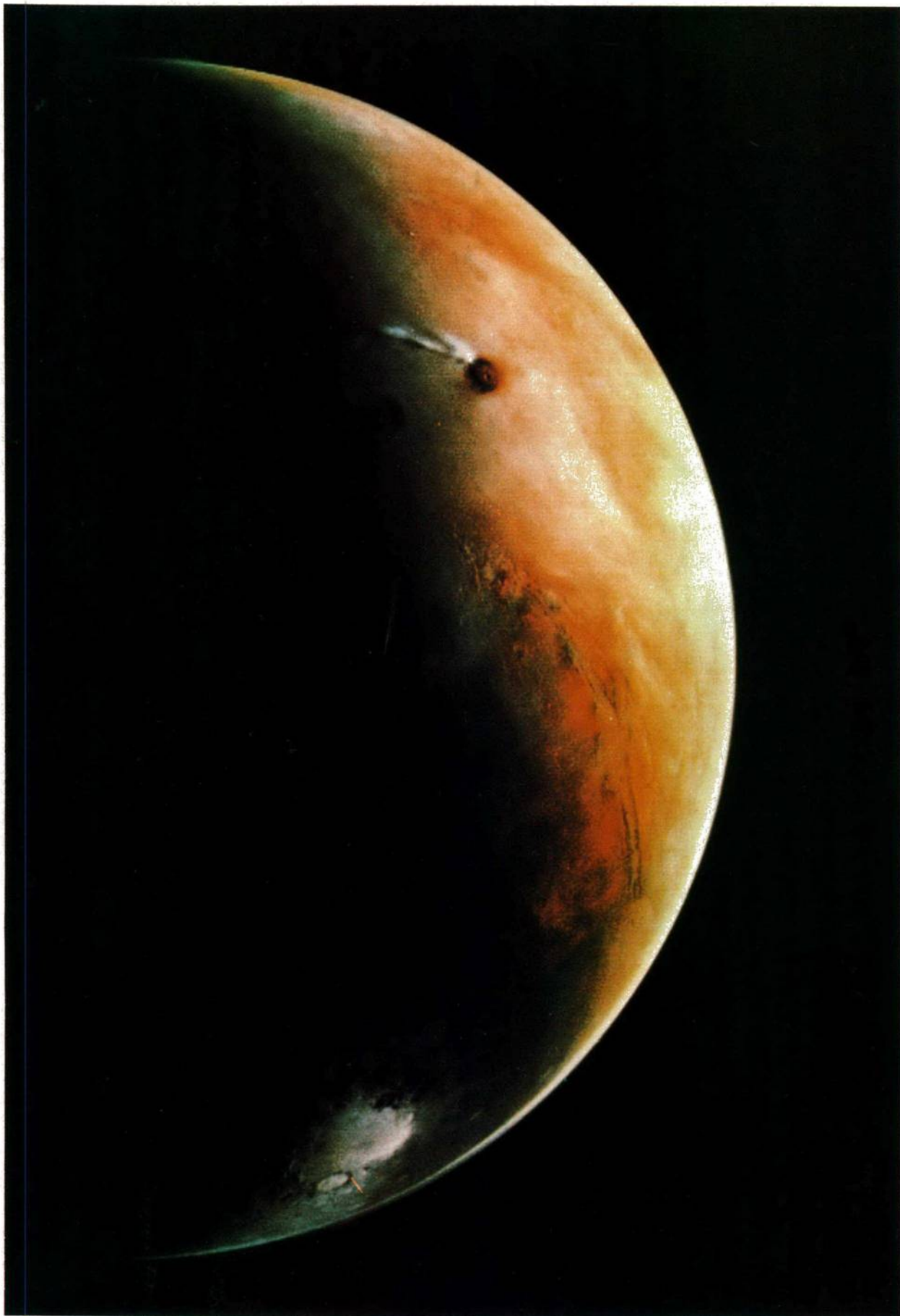
Published monthly by AstroMedia Corp., 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Copyright 1977 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, WI. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all new subscriptions, changes of address, renewals and subscription bill payments only to **ASTRONOMY**, Circulation Services, P.O. Box 186, Westchester, IL 60153 and allow six to eight weeks for new subscriptions and changes of address to take effect. To speed service on subscription correspondence, complaints, photographs, slides, manuscripts and editorial correspondence write **ASTRONOMY**, 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Telephone (414) 276-2689. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price, \$1.50. Subscription price: 1 year, \$12.00. Canada & Mexico: add \$3.00 per year. All other foreign: add \$6.00 per year. Additional office staff: William Stanfield, Production Assistant; Katherine King, Editorial Assistant; Judy O'Dair, Editorial Secretary; Stephanie Kiel, Administrative Assistant; Nancy Faustmann, Executive Secretary and Bulk Copy Sales. Accountant: Peter Trabbold. Consulting Editors: Thomas C. Brett, John Harmon. Contributing Artists: John W. Clark, Victor Costanzo, Adolf Schaller. AstroMedia Corp. officers: Stephen A. Walther, Chairman of the Board; Robert Maas, President; Penny Oldenburger, Vice President. Typesetting by Grafilm, Inc., Milwaukee, WI 53210. Separations prepared by Colorcraft, Inc., Milwaukee, WI 53216. Printed by E.F. Schmidt Co., Menomonee Falls, WI 53051.

MAN FINDS A NEW WORLD: MARS



Viking 2 rests on the Utopia Plains of Mars in a field of reddish rocks stretching to the horizon. Many of the rocks appear vesicular — filled with little holes — suggesting they have a volcanic origin. In the foreground is the body of the lander; the three color calibration charts mounted on it are used to “zero in” on the true colors of the exotic Martian landscape. On the level surfaces of the grayish housing (with the flag), you can see a fine layer of pink dust. The large round object at the top of the picture is Viking’s high gain antenna, pointed toward Earth. NASA photograph.





As Viking approached Mars in early August 1976, it took this dramatic picture of the sunrise side of the red planet. One of the giant volcanos of the Tharsis volcanic ridge — Ascreaus Mons — trails a plume of water-ice clouds. If you look closely, you can see the huge volcanic caldera at the volcano's peak. In the middle lies the great rift called Vallis Marineris, a canyon thousands of miles long. Near the bottom is the immense crater basin called Argyre; it appears white because its bottom is filled with frost. The south pole of Mars is at the bottom of the picture. NASA photograph.



A little over a year ago, two Viking landers set down on the surface of the planet Mars, and returned pictures and data to an anxious group of planetary scientists, astronomers, space buffs and journalists. The pictures were flashed around the world to the rest of mankind. In those instants, Mars became a world to human minds — a world of rock and desert, sand and sky, a world long seen in imagination but now seen directly through the eyes of an electronic robot resting on that distant planet.

We now know Mars as we know our own planet Earth and our moon — from ground level! Perhaps it is a mere change in perspective to see Mars not as a fuzzy image in a telescope, but as a world in its own right. But the perspective of human thinking changed, too. Much effort is now directed toward understanding this new world, for learning about Mars not only satisfies human curiosity about another world, but also can teach us lessons that apply to all planets, including Earth.

Both Mars and Earth have volcanos. On both planets, enormous amounts of lava and hot gases have poured onto the planetary surface. But Mars and Earth are profoundly different: Earth has great ocean basins and mountain chains formed by continental "plates" drifting across the surface of the globe. At the plate margins, volcanos and earthquakes are common. Mars apparently has no continental plates, but it does have volcanos larger than any on Earth. How are continental drift, earthquakes and volcanic activity on Earth related, and why is Mars different? Vital clues about the interiors of both planets may come from understanding their differences and similarities.

Earth is an abnormal planet in the solar system. Three-fourths of its surface is covered with liquid water; it has an atmosphere full of the highly reactive gas oxygen, and its limestone rocks suggest it once had a far more massive atmosphere. If Mars is made

from the same basic solar nebula "stuff" as Earth, why does Mars have so little atmosphere and water? The history of ancient Earth and Mars are part of the same tale of planetary formation and change. The basic problems in understanding Earth are clarified by studies of the other planets.

The question of life on Mars is still unanswered though the results of the Viking life detection experiments show it probably doesn't have much life now — and might never have had life. But the study of Martian conditions is still a part of the grand inquiry into the nature of life and its origins. What early environments led to Earthly life? If the conditions for life on Mars were once right to begin the blind and chancy chemistry of life, then why is there no life now? Have we explored enough of Mars to be sure there is no life?

Finally, we know that Earth's climate is unstable. As little as 10,000 years ago there were still giant glaciers in North America. We know that subtle changes in solar input can produce enormous changes in the amount of land available to man for farming. We know that Earth's orbit slowly and cyclically changes through the ages, and that Earth's climate shows a remarkable correlation with orbital changes.

In this issue, *ASTRONOMY* explores the climate of Mars. Our two authors — one a respected planetary scientist and the other a well-known and sometimes controversial science writer — present the intriguing polar findings that have led scientists to seek sources of cyclic change in Mars' environment, and the far reaching possibilities these findings reveal to probing humans. To some extent the articles overlap, because the polar regions and our understanding of the Martian climate are inextricably related.

During the next few decades, no human being will set foot on Mars. However, let us hope that the exploration of Mars will continue, for the problems of Mars are also the problems of Earth. 

THE POLAR REGIONS OF MARS

by
James Cutts

Nothing in science is quite so exciting as when the search for one phenomenon results in the discovery of another, even more remarkable and largely unrelated fact of nature. In 1972, the Mariner 9 spacecraft was programmed to photograph suspected glacial features near the south pole of Mars. To the immense surprise of the scientists, the glacial features they sought were absent; instead, the pole was dominated by a strange landscape of arcuate and sinuous bands arranged in a complex spiral pattern around the pole!

The high resolution closeup views were even more intriguing. Each one to three mile (two to five kilometer) wide band was made up of regularly spaced terraces with a perfection of form unusual in geological features. These terraces were evidently the surface exposures of layers in a surface covering of snow and dust about a mile (1.6 kilometers) thick.

The layered deposits are huge — covering most of the surface of Mars north and south of 80 degrees latitude, even extending down to 70 degrees latitude in a few places. For much of the Martian year, they are entirely covered by a blanket of polar snows consisting of carbon dioxide with traces of water ice. Then as summer approaches, the snows recede to a smaller residual polar cap which survives yearround just like the polar glaciers that we have on Earth.

The layered deposits partly underlie the remnant perennial polar caps (those regions that stay unmelted throughout the cool polar summers). From Mariner 9 and Viking orbital pictures, the Mariner 9 and Viking teams found the terraced layers that compose them are between 30 and 150 feet (10 and 50 meters) thick, and over expanses of hundreds of miles, they lie level or nearly level. Each layer has a nearly constant thickness, and we think that they are made of dirty ice — a mixture of dust and snow. When we see terraces from orbit, the surface has been eroded — probably by wind and wind-blown sand — into the complex systems of sinuous ridges and valleys visible in the photomosaic map (see page 12) made by the Viking orbiter last year. We can see the layers because they must differ in color and hardness (as do sedimentary rocks on Earth), so that the ero-

sion process has etched the layers as steps into the sides of the cliffs and slopes of the ridges and valleys.

The eerie precision of the layers and their symmetry suggested that natural cyclical forces (of a kind which did not usually make a large scale imprint on planetary surfaces) had created these weird polar landscapes. So scientists began checking sources of cyclical forces which could affect geological events on Martian surfaces. Internal planetary processes such as vulcanism were considered. But volcanos occur in the equatorial regions of Mars, and although vulcanism can be cyclic and not as capricious as we sometimes think, vulcanism at best could provide only a partial explanation for features occurring in the Martian polar regions. Internal processes in the sun which might have given rise to fluctuations in solar radiant energy output over geologic time, and corresponding variations in the energy impinging on Mars, were also unlikely to be regular enough. Both hypotheses also suffered from another crucial drawback: Neither the interior of Mars nor the sun is understood at present. No one could assert with any degree of certainty that cyclical processes do in fact occur — let alone predict their characteristic periods.

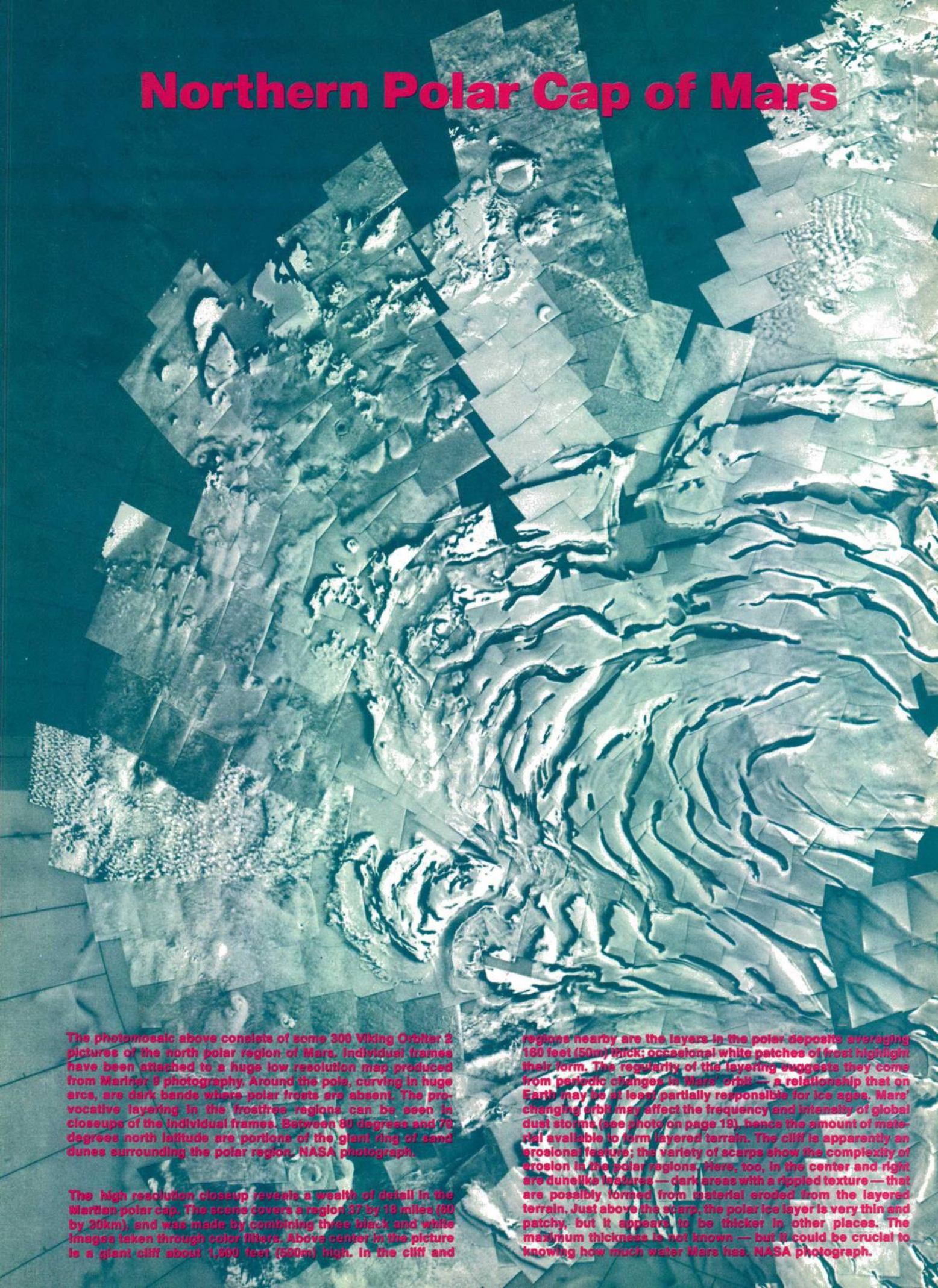
But that was not the case with a third possible source of cyclical natural forces on the Martian surface. Variations in the planet's orbital and rotational attributes are not only certainly cyclic, but the underlying physics — Newton's gravitational theory — allows exact mathematical calculation of what happened.

There are several kinds of periodic variations now

From an orbital "eagle's eye" perspective, the Viking orbiters zeroed in on many fascinating Martian landscapes. This image is a high resolution color view of part of the belt of sand dunes near the north polar cap. The dunes form a sharp edged dark band near the top of the image. Martian sand is dark — unlike Earth sands which are usually light colored — because erosion processes tend to leave the hardest mineral grains (which on Mars are dark) intact. The middle of the image shows a flat desert region. In the lower left is a region of mottled terrain of unknown origin, a strip of layered terrain (its layering clearly visible in this view), and finally a pinkish-white region of polar frosts. NASA photograph by the Image Processing Laboratory at JPL.



Northern Polar Cap of Mars



The photomosaic above consists of some 300 Viking Orbiter 2 pictures of the north polar region of Mars. Individual frames have been attached to a huge low resolution map produced from Mariner 9 photography. Around the pole, curving in huge arcs, are dark bands where polar frosts are absent. The provocative layering in the frost-free regions can be seen in closeups of the individual frames. Between 80 degrees and 70 degrees north latitude are portions of the giant ring of sand dunes surrounding the polar region. NASA photograph.

The high resolution closeup reveals a wealth of detail in the Martian polar cap. The scene covers a region 37 by 19 miles (60 by 30 km), and was made by combining three black and white images taken through color filters. Above center in the picture is a giant cliff about 1,500 feet (500 m) high. In the cliff and

regions nearby are the layers in the polar deposits averaging 160 feet (50 m) thick; occasional white patches of frost highlight their form. The regularity of the layering suggests they come from periodic changes in Mars' orbit — a relationship that on Earth may be at least partially responsible for ice ages. Mars' changing orbit may affect the frequency and intensity of global dust storms (see photo on page 19), hence the amount of material available to form layered terrain. The cliff is apparently an erosional feature; the variety of scarps show the complexity of erosion in the polar regions. Here, too, in the center and right are dunelike features — dark areas with a rippled texture — that are possibly formed from material eroded from the layered terrain. Just above the scarp, the polar ice layer is very thin and patchy, but it appears to be thicker in other places. The maximum thickness is not known — but it could be crucial to knowing how much water Mars has. NASA photograph.



1. At the onset of polar activity, the polar regions may have been wind-modified ancient volcanic terrain.



2. During the first period of deposition, layers of dust and ice accumulated, decisively controlled by a process linked to the orbit of Mars. The deposits were massive — about 4 miles deep.



3. Erosion then removed some of the embedded dust in a complex pattern of scarp and channels.



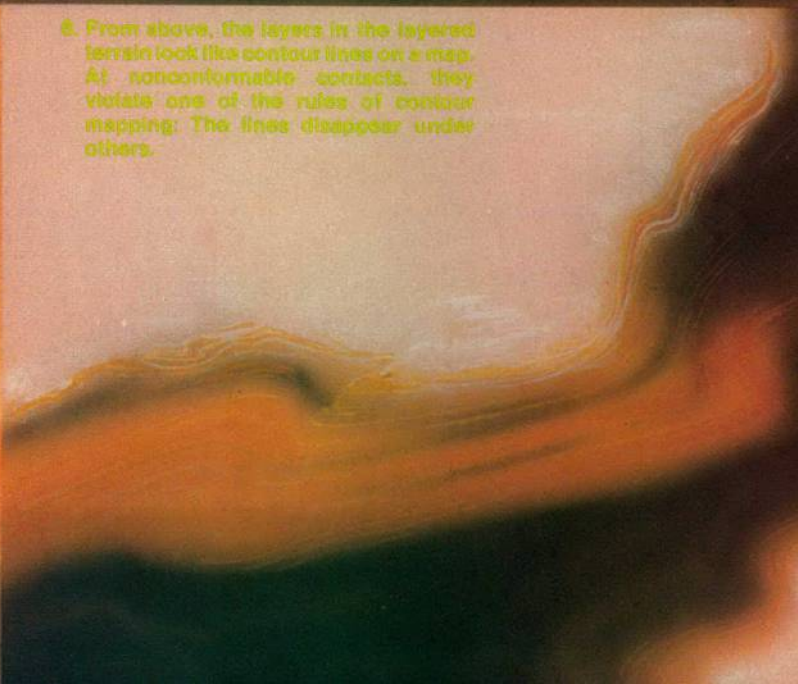
4. More layered deposits accumulated, burying the eroded landscape. New layers were formed over the old landforms, but the new layers did not match the older layers.



5. A second period of erosion eventually uncovered deposits from both periods of deposition. In a few places, the nonconformable contacts revealed evidence of previous erosion.



6. From above, the layers in the layered terrain look like contour lines on a map. At nonconformable contacts, they violate one of the rules of contour mapping: The lines disappear under others.



thought to have possible relationships to polar features on Mars. The first is a 51,000 year periodicity in the position in the Martian orbit where summer and winter occur, and a shift in the orbital location of Mars' closest approach to the sun. These slow shifts are brought about by slight gravitational interactions between Mars, the other planets and the sun, acting over long periods of time (see diagram on page 22).

At the surface of Mars, the consequence is an alternation in the severity of the seasons. The eccentricity of the Martian orbit is large relative to that of Earth. Near perihelion (when Mars is nearest the sun), the solar radiation falling on the surface is 1.45 times greater than that at aphelion when Mars is farthest from the sun. When perihelion coincides with the summer season in one of the hemispheres, temperatures in that hemisphere (particularly at the pole) are unusually high. That hemisphere gets a "double dose" of heat — not only from its summer, but from its nearness to the sun. At these times, winters are "double dosed" too, occurring at maximum distance from the sun. When the summer season and perihelion get "out of step" 25,000 years later, one Martian hemisphere will have cool summers and warm winters — a "minidose" of the seasons.

Theories also predict that the eccentricities and inclinations of all the planetary orbits participate in periodic variations. These variations happen to be unusually large for Mars' eccentricity: There is one cyclic variation in the orbital eccentricity lasting 95,000 years, and another cycle of 2,000,000 years! Mars' orbit turns out to vary from its present .093 (slightly oval) to as much as .14 (quite oval) and as little as .004 (almost circular). This variation produces periodic changes of as much as 30 percent in the peak solar energy falling on Mars' summer hemisphere in any year!

A larger effect on the Martian climate, recently recognized by William Ward of the Smithsonian Astrophysical Observatory, is caused by variations in the planet's obliquity. The obliquity — an angle made by the planet's rotation axis with its orbit plane — will undergo periodic excursions due to the perturbations of orbital inclination (see diagram on page 22). But still larger variations — peculiar to Mars — arise from an interaction between the planet's rotational and orbital motion. As a consequence, the obliquity of Mars has significant periodicities at 120,000 and 1,200,000 years. The Martian obliquity varies from the present 25.1 degrees to as much as 35.5 degrees and as little as 14.9 degrees. These variations produce truly dramatic long term variations of more than 40 percent in the solar heat falling on the Martian poles. Thus the search for Martian glaciers and glacial features (not found) spurred the discovery of dramatic orbital variations. It seems very likely that one or more of these astronomical periodicities are reflected in the polar layering. The obliquity variations (because of their much larger effect on the polar heat flow) now appear to be the most likely candidate.

However, scientists don't understand how variations in sunshine and heat input actually cause the observed layering to the ice deposits at the poles, so the connection with the obliquity variation is speculation. All that can be said for certain is that the Martian atmosphere "mediates" the creation of an astronomical record in the surface rocks.

How did the deposits get there? Scientists speculate that at an earlier epoch in Martian history, snow and dust were laid uniformly over the entire polar cap — perhaps a few inches each winter for a few centuries or millennia. Then the perturbations of the planet's orbit or rotation caused Mars to become warmer. Snowfall stopped or became less, while at the same time Mars had more and bigger duststorms and the poles accumulated a layer of dust. The cycle then ran cold again, and the dust and snowfall returned. In this manner, Mars may have built its massive layered polar caps. In such theorizing, many things are important: whether dust is caught and held by the snows, snowfall rates, the number of duststorms and the paths they follow on the Martian globe. We need to know a great deal more before we can say much more.

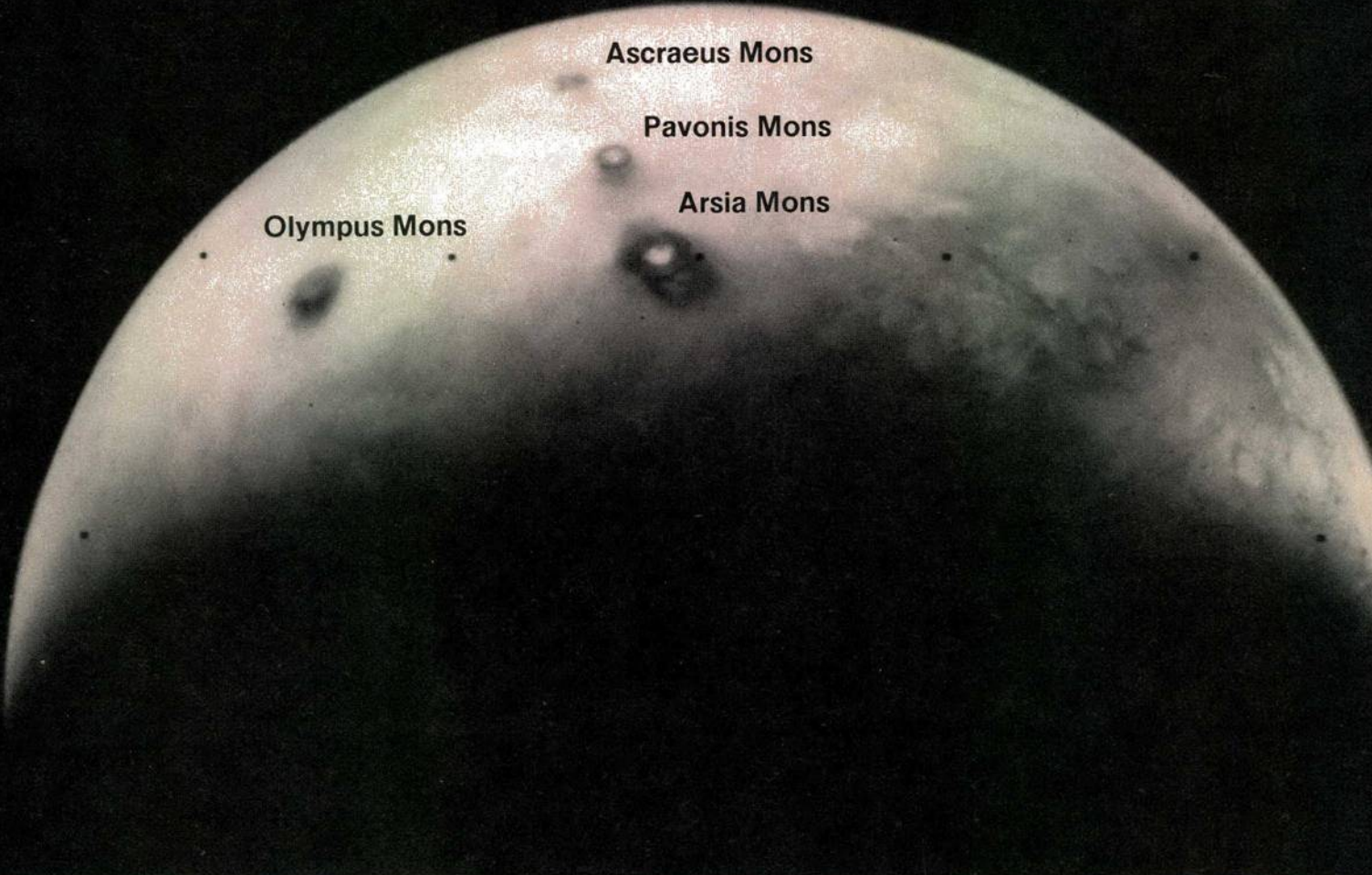
The Viking II orbiter had begun to systematically collect high resolution pictures in the north polar region — pictures needed to solve some of these basic questions about periodic climate change on Mars. But once again, a remarkable surprise discovery turned up. Recently another feature of the polar layered deposits has emerged: a major imperfection (in geological terms, an *unconformity*) in the regular pattern in which the layers were laid down (see the picture on page 14). This unconformity suggests that a single event of planetwide significance disturbed the orderly evolution of the planetary surface. Speculation has centered on the role of the Tharsis-Syria rise — the great volcanic center in the western hemisphere — whose gradual creation could have literally tipped Mars off its rotation axis.

The picture that emerges from the unconformity is a discontinuity in the formation of the polar caps — an event buried in the Martian past. The layering process that built a layer over thousands of cold years, then stopped, and then built again in accord with the slow oscillations of the Martian orbit, must have begun with the formation of near horizontal layers covering an ancient polar surface with craters and landforms like the rest of Mars. As millions of years rolled by, hundreds of layers accumulated until the polar cap deposits were vast, smooth and featureless.

But something changed — presumably related to the slow formation of the massive Tharsis Ridge volcanos which ultimately changed the balance of the whole planet, and millions of years of warmer climate followed. Snowfall stopped and erosion set in, cutting deep valleys and canyons into the thick icy mass of the polar cap. Then the pattern shifted again, and after geological ages of warmth, the snows returned. Again the layers built up, this time on top of the



Volcanos of Mars



Ascræus Mons

Pavonis Mons

Arsia Mons

Olympus Mons

valleys cut into the older polar cap. The ordering of the layers that Viking has photographed is disturbed — obviously not continuous — history revealed in the layers of dirty snow.

Another important discovery emerging from Viking II photography is that of a vast sea of dark sand dunes surrounding the north pole. The dunes occupy the same region of Mars on which Earth based astronomers saw a "wave of darkening" as they viewed the planet through telescopes. The sands appear to have come from rocks in broad tracts of terrain in the northern hemisphere. In places the dunes have swept over the layered ice deposits. No comparable sand deposit occurs in the southern hemisphere, and this fact poses more questions about the evolution of Mars.

For example, could sand be migrating between the poles in response to periodic variations in climate? Some scientists have inferred that boundaries of the dark markings in the equatorial regions migrate to

and fro as a consequence of long-term periodicities in the distribution of winds on Mars. But blowing large amounts of sand across the surface of a planet is such an inefficient process that it seems unlikely pole-to-pole transfer could be accomplished in much less than two million years (the period of the longest known astronomically induced climatic cycle). Perhaps only the dark minerals eroded from the northern hemisphere plains can survive transport to the pole in the corrosive environment of the Martian surface — exposed to water, carbon dioxide, ozone and ultraviolet light. On the other hand, maybe the global topographic differences impair surface transport of dune materials toward the south pole or somehow trap them on the way. While many questions remain unanswered, the dunes seem related to the polar caps, and so to the whole history of Mars.

Thus, the search for the expected glacial features has led science into striking new discoveries about the long term history of Mars. But before the picture is complete, more data and study are required. Scientists hope to find answers as they continue to acquire data with the Viking spacecraft, and plan future explorations of the red planet. 🌌

In this Mariner 9 mosaic of Mars, the north polar ice cap appears at the top. This picture was taken in the late northern spring and shows much of Mars' northern hemisphere; the polar cap is shrinking. The complex channeling seen on pages 12 and 13 can be related to this larger picture of the whole planet. In the center of the disk are fractured regions partially flooded by lavas pouring from the Tharsis volcanos (lower right, forming a line of three). At the extreme lower right is the end of the giant chasm Vallis Marineris, named after the spacecraft that revealed it to mankind. The giant volcano Olympus Mons appears at lower left. NASA photograph.

James Cutts is a research manager in the Planetary Sciences Institute division of Science Applications Inc., a firm that does space research for NASA and the United States government. He has been active in studying the orbital and flyby imagery from Mariners 6, 7 and 9, and is now involved with Viking.

MARTIAN CLIMATE: PAST, PRESENT and FUTURE

by
John Gribbin

Each successive advance in our ability to observe the surface and atmosphere of Mars has brought new theories about the climate of the red planet. The oldest modern pictures, dating back to the 1890s and the early part of the 20th century, saw Mars as a planet rather like Earth, but drier. Civilized beings, perhaps older and wiser than the human race, were imagined as the architects of a great canal system bringing water from the polar regions to drought stricken lower latitudes, and changes in the markings of Mars were interpreted as the seasonal bloom and spread of vegetation irrigated by those canals. And all this was sober scientific theorizing — not science fiction — until a few decades ago.

With the more exotic trimmings — the canals and the intelligent Martians — excised from the models, this basic idea remained around even into the 1960s, when it was still possible to take seriously the idea that “waves of darkening” spreading out from the Martian poles during the Martian spring could mark the growth of some form of vegetation. But the Mariner 4, 6 and 7 photographs completely upset the applecart. Such models became unacceptable in the

light of new evidence. Since then, first Mariner 9, and now the two Viking missions, have piled some of the apples back on the cart — but in a rather different arrangement. Curiously, the idea of Mars as a planet which once had a wetter climate and denser atmosphere, more suitable for life, has been restored. The timescale, however, has stretched from a few thousand years to several hundred million years of planetary history, at least.

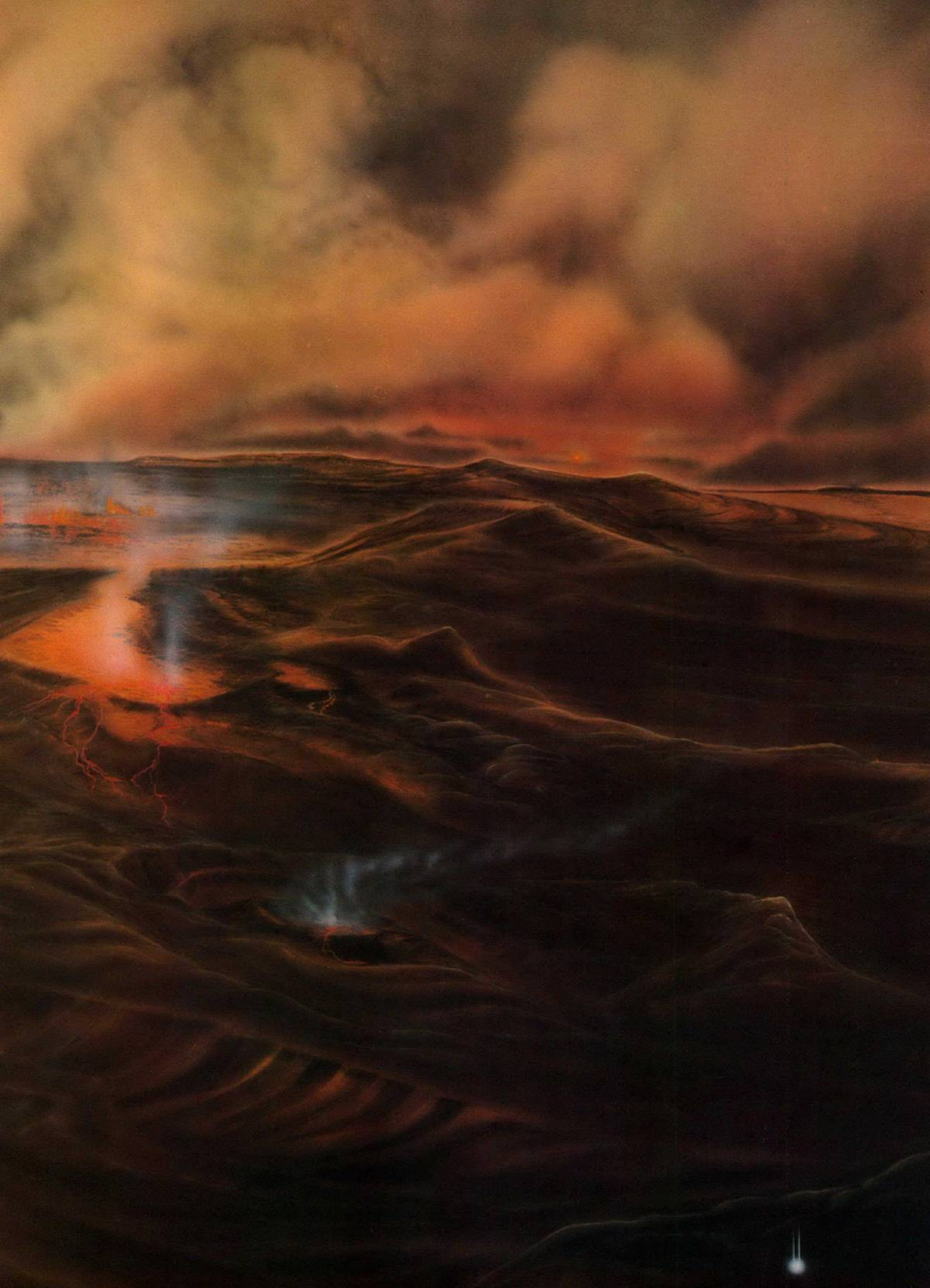
The pictures from the flyby Mariner 4, and later Mariner 6 and 7 missions, rocked planetary physicists by showing Mars (or, at least, the narrow strip photographed then) as a barren world marked by

From Viking Orbiter 2, a bright turbulent cloud of dust spreads across the Argyre Basin (see the photo on page 8). The duststorm was about 180 miles (300km) across when this picture was taken. During the winter, the floor of Argyre is covered with frost. At the time this picture was taken, spring was approaching — so only half the basin floor is ice covered. Large basins like Argyre and Hellas seem to be the frequent sites of duststorm formation. In the low areas of the basin the ice has a golden hue, but in the mountains surrounding the basin (near the bottom of the picture) the ice shines white. NASA photograph.

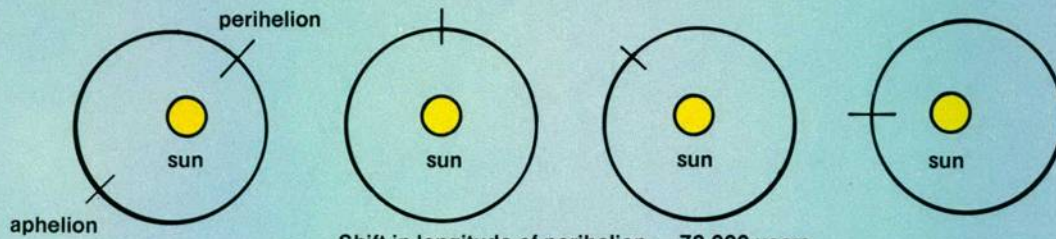




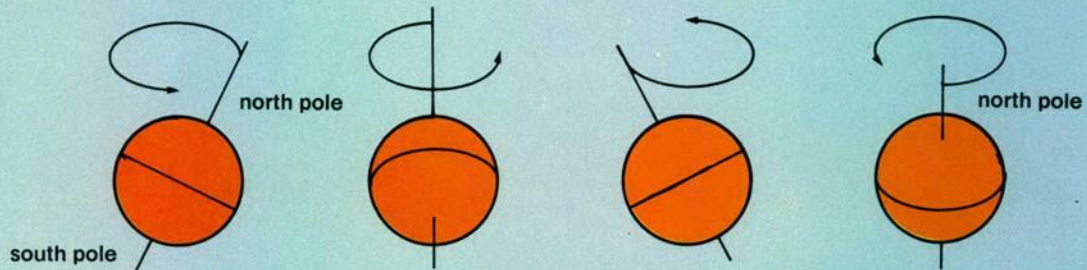
Churning internally, spewing molten rock, a primitive Mars builds a giant volcanic shield. When the Tharsis ridge was forming — perhaps several billion years ago — Mars may have spun on a different polar tilt, the mass of lava and rock forming the ridge and its volcanos ultimately throwing the entire planet off balance, changing the polar tilt and the climate of the planet! This scene, an ancient sunset over a smoldering volcanic caldera, may have occurred long before life evolved on the distant inner planet Earth. Artwork by Mark Paternostro.



Cycling the Martian Climate: Orbital Effects

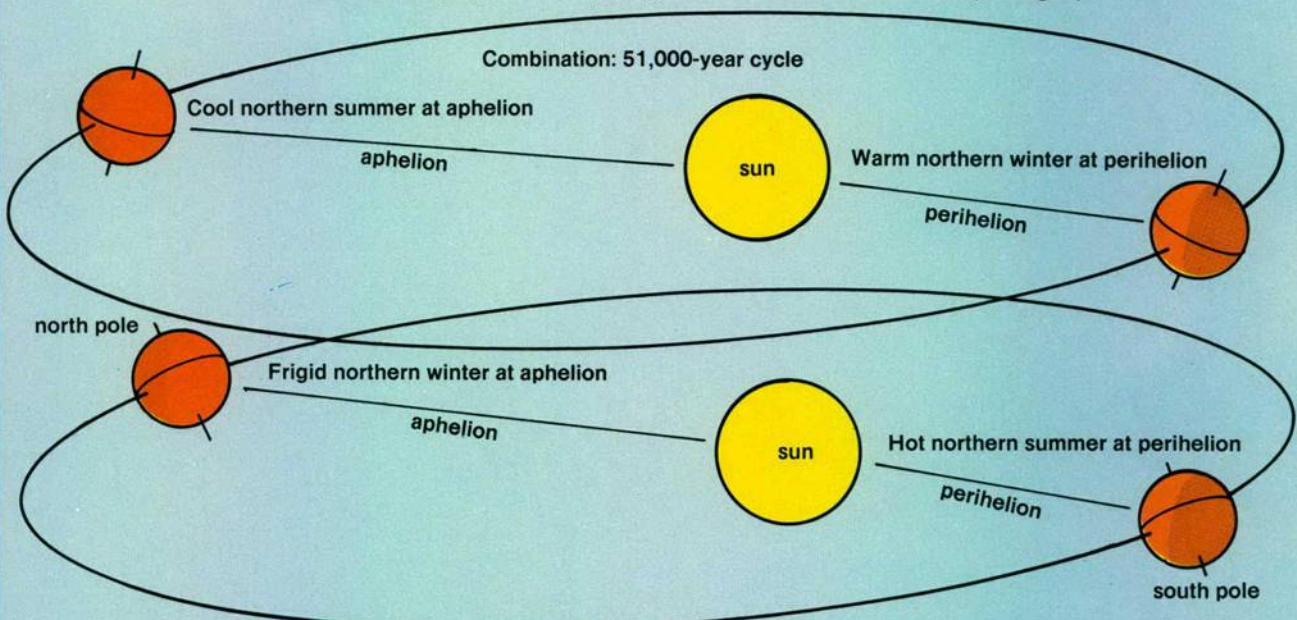


Shift in longitude of perihelion — 72,000 years



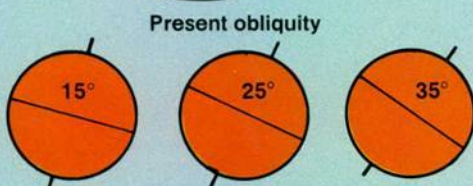
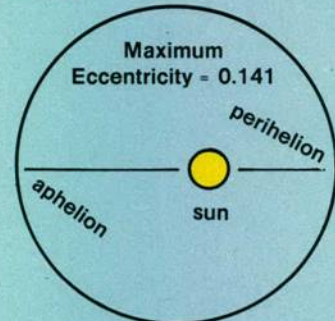
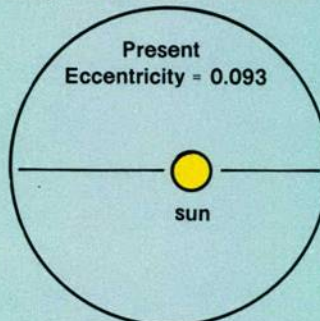
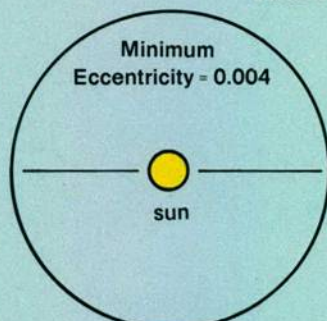
Precession of equinoxes — 180,000 years

Mars wobbles like a spinning top



Combination: 51,000-year cycle

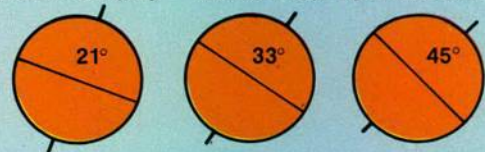
Variations in eccentricity Mars' orbit "stretches" and "rebounds"



Present obliquity variation

Variation in obliquity

Martian "top" tips more and less



Obliquity variation before Tharsis Volcanoes

craters, strikingly similar to our moon. It looked for a time as if there would be no need for *any* models of the Martian climate; but Mariner 9, photographing the whole planet in the early 1970s, showed that the quick snapshot views of the earlier missions were not typical. Indeed, Mariner 9 found so much evidence of erosion, features looking just like those carved by running water on Earth, that climatologists offered a new and splendid array of theories and speculations about the climate of Mars, and suggestions of where the former water had gone.

Liquid water cannot exist on Mars today. The temperature of the Martian surface is low enough to freeze water, while the pressure is so low that frozen water does not melt into liquid, but goes straight from the solid to vapor form if warmed — just as solid carbon dioxide (dry ice) does here on Earth. If there was running water on Mars as erosion features suggest, Mars must have been warmer, and its atmosphere thicker, in the past. In fact, those changes go hand in hand; a thicker atmosphere would help keep the surface warmer by the greenhouse effect (acting as a blanket around the planet), while a warming of the planet, releasing vapor into the air, would help thicken the atmosphere.

Realization of this link led to the most grandiose idea to come from Mariner 9 — that of deliberately engineering the climate of Mars to produce warmer, wetter conditions, eventually perhaps leading to a new home in space for mankind. Unfortunately, this idea depended on evidence indicating the Martian polar caps consisted largely of frozen carbon dioxide, which might be evaporated to provide a thicker atmospheric blanket, with water thawing out of frozen underground pockets as a consequence. Just *how* the polar caps could have thawed remained something of a problem; a favorite solution was to dust them with black material to absorb heat — a rather expensive operation, even if the materials used came from the asteroid belt. But such practical snags no longer have any relevance, since Viking orbiter observations now show that the Martian polar caps, like those of Earth, are mostly made of water ice. Even if the Martian polar caps melted, they would not provide enough atmosphere to set up a permanent greenhouse effect strong enough on its own to create a warm, wet Mars.

Maybe man cannot modify the Martian climate after all. But nature has certainly achieved that feat since the formation of the solar system, and the long-term history of the climate now seems fairly clear, as outlined over the past couple of years by a team from Cornell University.

One of the most striking insights into the sort of timescale we must think about when dealing with models of the warm, wet Mars was provided by studies of the way craters overlap the features that are thought to be old river courses. Where a crater breaks into the river feature, it's obvious the river is older than the crater. And where a river is cut by several craters, it's clear that the river must be very old indeed — for although meteorites have rained

down on Mars pretty steadily over the eons, a river is a small target and will be hit rarely. With the numbers put into the statistics for current cratering rates, we find confirmation that many (if not all) of the biggest and best features on Mars attributed to running water are certainly *hundreds of millions of years old*.

The warm, wet phase of Martian history was a short-lived, spectacular flowering in the planet's youth.

This discovery ties in very neatly with the discovery of large volcanos on Mars, with some of man's best theories about the formation of the planets, and with ideas about the early evolution of Earth's atmosphere. Mars, Earth and Venus would have developed their ancient *primary* atmospheres from volcanic activity and outgassing from their rocks — primitive atmospheres rich in compounds such as methane and ammonia. The thick early atmosphere on Mars would have produced a strong greenhouse effect, keeping the planet warm and the rivers flowing. But, on Mars, the weaker gravity allowed many of the gases in the primary atmosphere to escape.

Chemical reactions, stimulated by sunlight, would have broken down some of the volcanic gases, releasing hydrogen from the methane and ammonia to escape from the feeble tug of Martian gravity. Leftover carbon and nitrogen atoms, too massive to escape easily even from Mars, combined chemically with surface rocks and were lost from the atmosphere. Oxygen, produced when sunlight broke up water molecules in the primary atmosphere, combined with carbon to make carbon dioxide. Gradually, the original thick, wet and warm blanket of atmosphere around Mars evolved into the thin, dry carbon dioxide atmosphere we find there today. The rivers dried up, the planet cooled, and all the free water on Mars froze.

There might well be quite a lot of frozen water left on Mars. Indeed, virtually the whole planet may be swathed in a shell of ice hidden below the dusty surface. When volcanic heat reaches this frozen shell, even today occasional great floods may burst forth, producing the jumbled flood plains found in some regions of the planet. But such flooding would be short-lived, with the liquid water rapidly freezing as it flowed away from the source of volcanic heat.

Very much the same processes happened on Earth, but Earth's greater gravity retained a thicker atmosphere. This, plus the fact that we are closer to the sun than Mars, kept Earth warm and the seas liquid. In those seas, life developed. And living organisms were important in eventually transforming the atmosphere by releasing large quantities of oxygen into it by photosynthesis from primitive plants.

On Venus, closer still to the sun and even hotter than Earth, conditions seem to have gone to the other extreme. Venus today has a hot, thick atmosphere sweeping across hot deserts beneath. Only relatively minor "local" differences have produced three planets with climates as diverse as those of Venus, Earth and

Mars from the same basic planetary building blocks. By studying all three planetary atmospheres, climatologists are moving toward understanding — better than ever before — the workings of the atmosphere and climate of Earth. But there are still some puzzles about the Martian climate, and still strong hints that some kind of regular, short-term (by astronomical standards) climatic changes occur on Mars even today.

Again, evidence comes from the Viking orbiters. Indeed, to students of planetary atmospheres and climates, the orbiters have proved even more interesting than the Viking landers (except for the landers' discovery of nitrogen in the Martian atmosphere). Photographs of the polar caps show that the edges of the ice sheets there form a series of steps. The caps are not single sheets, but seem to have been formed in layers, or *laminae*. The obvious explanation is that waves of warm and cool climate have swept across the polar regions, melting and freezing the polar caps to produce the laminae.

There is much evidence — including lander measurements of noble gas and nitrogen isotope relics of primitive atmosphere — that the early Martian atmosphere differed from the present one, that stream beds are very old, and that the polar cap layers are fairly young. And the latest idea to explain these observations, from a team at NASA-Ames Research Center and Cornell, is that the obliquity of Mars — the extent to which Mars "nods" toward and away from the sun — may have undergone a major shift, when the volcanic event that produced the Tharsis ridge occurred.

Like Earth, Mars orbits the sun with its spin axis slightly tilted relative to the orbit plane. This is just the effect that produced seasons: When the north pole is leaning toward the sun we have summer in the northern hemisphere, and so on. If this tilt became big enough, the Martian poles would get warm enough in their summers to melt ice. According to calculations by Dr. Owen Toon of NASA-Ames, when the obliquity (tilt) is 35 degrees or more, Martian polar temperatures rise above freezing continually for periods of 40 days or more.

At present, the obliquity of Mars is only 24 degrees, so its poles are frozen. But the obliquity varies regularly over a range from 11 to 37 degrees — a "wobble" produced by spin effects of an imperfect sphere moving under the influence of the sun's gravity and that of the other planets in the solar system. So even under present conditions, there may be regular epochs when the poles of Mars become just warm enough to melt ice!

But the imperfections in the sphere of Mars have not always been the same as they are today. The shape of a planet can be changed by volcanic activity; the impacts of large meteorites, and even changes in the ice cover of the poles, can also change the oblateness of the planet, altering its balance and the way it wobbles in its orbit around the sun. Calculations

made by Toon in collaboration with Drs. J. A. Burns and Bill Ward show that if the oblateness of Mars were only eight percent less, the whole pattern of the planet's obliquity variations would shift into a new, stable pattern, with the tilt wobbling an average of 33.5 degrees, but sometimes reaching as much as 45 degrees. The Tharsis feature alone accounts for 6.4 percent of the oblateness of Mars today. So before Tharsis formed, Mars could very well have been tilted into this other stable state — a state in which the poles often melted.

This has very big implications for the history of the climate of Mars. Summers on ancient Mars may have been very warm (by Martian standards) with plenty of water being evaporated into the atmosphere — perhaps enough to build up further warming through the greenhouse effect. The water, condensing and falling as rain in equatorial regions, could be just the thing to explain the river features found at low latitudes. Most important of all (if this picture is correct and if Mars *did* tilt more toward the sun in the past), conditions suitable for free water might have persisted long after the primary atmosphere changed into something like its present form. When volcanic activity began and formed the Tharsis ridge, Mars shifted into its present pattern of obliquity, causing the poles to cool and freezing the water. Since then, Mars has only rarely nodded enough for the polar caps to thaw partially before refreezing in the layers shown in the Viking orbiter photographs. Occasional brief flashes — separated by tens of thousands of years — are all that remain of the former glory of a wet Mars!

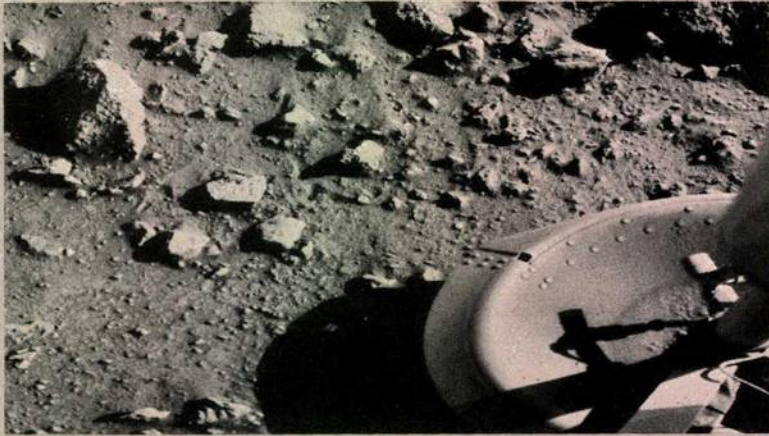
But perhaps the oblateness of Mars will be changed again? One theory suggests that the location of Tharsis and Olympus Mons together on one side of Mars, with no large volcanos on the other hemisphere, means that the planet is only now developing the kind of volcanic activity that has produced continental drift on Earth. As the rest of the planet "comes to a boil", the oblateness might well decrease as the bulge of Tharsis is balanced by bulges on the other side of the planet. With increased volcanic activity — plus warm poles — Mars could become a very interesting prospect indeed, with liquid water and an atmospheric blanket thickened by a new outpouring of volcanic gases.

The snag is that none of this can happen quickly; such events will take as long as the events which switched off the previous wet era — hundreds of millions of years. It seems that as far as *our* civilization is concerned, we have reached Mars at just the wrong time! Still, the history of Mars offers mankind many useful lessons in understanding planetary history.

John Gribbin is a member of the Science Policy Research Unit of the University of Sussex (United Kingdom), where he is studying climatic changes on Earth and their effects on agricultural productivity. His book on these problems, *Forecasts, Famines and Freezes*, was published last year by Walker (New York).

ASTRONOMY *is.* . .

exploration



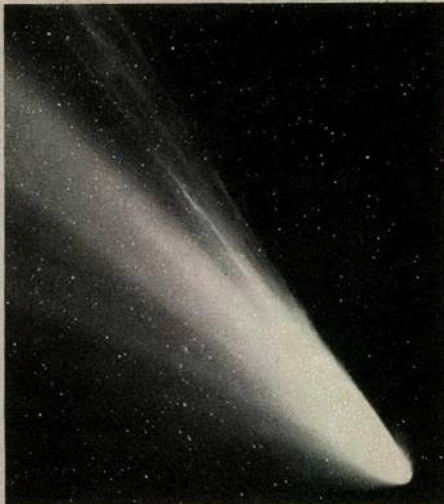
galaxies



nebulae



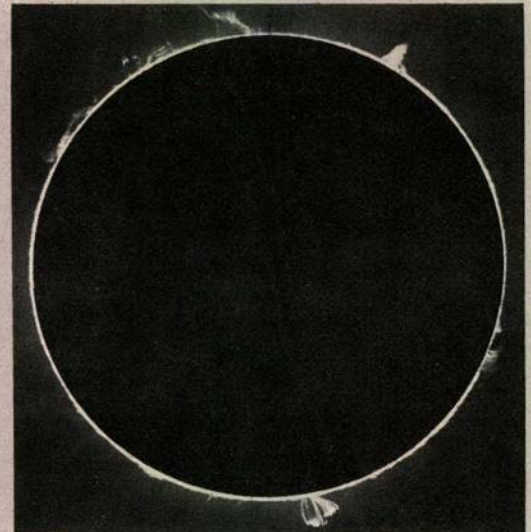
comets



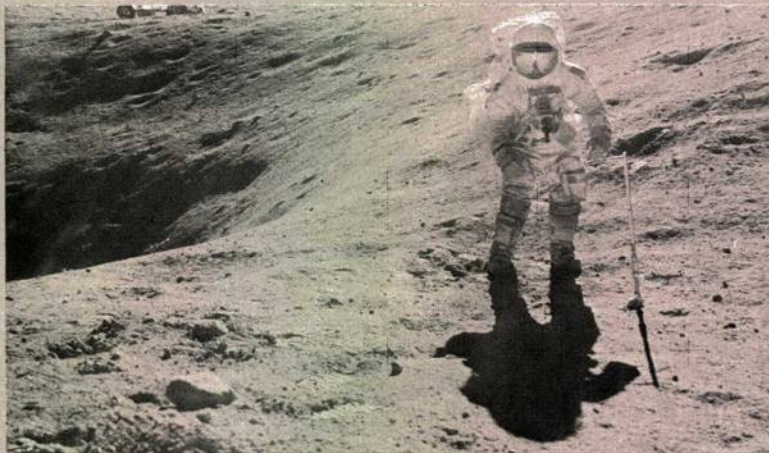
timeless



spectacular



dramatic



ASTRONOMY *is* The World's Most Beautiful Astronomy Magazine

Established August 1973. Published monthly by AstroMedia Corp.

Subscription price: 1 year (12 issues), \$12. Canada & Mexico: \$15 per year. All other foreign: \$18 per year.

ASTRONOMY, 411 E. Mason St. - 6th Floor, Milwaukee, WI 53202. Phone (414) 276-2689

HEADQUARTERS FOR

"Super"

CELESTRON® TELESCOPES

from TUTHILL

Demonstrations and
Personal Consultations

IMMEDIATE DELIVERY



C-88 on Celestron 8 on a mini mount.

When you buy one of the famous Celestron telescope packages from us, we make it into a "Super" CELESTRON by giving you your choice of any three of the following valuable Tuthill Custom Engineered Accessories FREE.

1. Solar Skreen® and Cell. SAFE full aperture, unsurpassed solar filter — fits over front of scope to block all heat. U.S.A. Protected by USA Patent #3,897,140. No mounting work required. No glue or magnets required — controlled density.

Value C5 \$41, C8 \$48, C14 \$95 or

2. Luna Shade* and Cell. Full aperture filter for reducing lunar glare and improving contrast. Mounts in seconds.

Value C5 \$41, C8 \$48, C14 \$95 or

3. Polaris Pointer * Special modification to Celestron wedge to let you aim your polar axis on Polaris with finger tip control of azimuth and elevation without the need to level your tripod or know your latitude.

Value C5 & C8 \$44, C14 \$99 or

4. Precision Celestial Pole Finder* Gives accurate indication when your scope is exactly aligned on the Celestial Pole. This special finder telescope and bracket is a must for precision alignment for astrophotographers.

Value C5 & C8 \$63, C14 \$88 or

5. No Du* Cap Ends frustration from normal dewing problems. Unheated model stores on scope, has a grey finish with black flock lining. Does not interfere with storage in box or with counterweights.

Value C5 \$36, C8 \$42, C14 \$81 or

6. Micro Drive* Increases fine control of R.A. by a factor of 10. Manual slow motion makes positioning objects precisely in the field of view a real breeze.

Value C5 & C8 \$49, C14 N.A. or

7. R.A. & Dec Light Set. Eliminates the need for a flashlight. Built-in battery with red long lived L.E.D's in molded self-contained case with a switch for brightness adjustment.

Value C5 & C8 \$48, C14 N.A. or

8. Mini Mount* New improved lightweight combination wedge and tripod ideal for traveling. Rigid stable support for table top viewing with infinitely adjustable latitude setting.

Value C5 & C8 \$49, C14 N.A. or

9. NEW Fitted Carrying Case Liner. Molded foam support pockets for all key accessories and C8 scope.

Value C8 (only) \$54

PLUS 20% off on all the above that are not FREE

PLUS An extra orthoscopic eyepiece FREE

PLUS FREE shipping to all parts of USA in special containers

PLUS Special Astronomical Handbooks FREE

PLUS Our FREE Laser collimator alignment re-check before shipment and for one year after purchase. (value \$50)

PLUS Unlimited authoritative advice and instruction in astronomical principles including astrophotography.

PLUS A referral awards program. (value \$50 PLUS)

PLUS Discounts on custom engineered accessories still on the drawing board.

STRAIGHT TALK ABOUT EYEPIECES

Of course no eyepieces are perfect in every respect BUT eyepieces are the final key to good telescope optical performance. We offer the following eyepiece choices:

Kellners \$16.00 ea.
Orthoscopes \$23.00 ea.
Erfles \$28.00 ea.
Brandons \$47.50 ea.
and
Clave/Plossls \$61.00 ea.

These eyepieces span the viewing requirements of the casual observer to the most demanding professional. Write for a copy of an independent users report #Z-1000 for a detailed discussion of the essential points of comparison on these critical elements contributing to your astronomical enjoyment and satisfaction.

TRAP A STAR



IDEAL FOR ALL FINDERS OR GUIDE SCOPES

- Self-contained switch and replaceable 6-volt battery
- Dual red light-emitting diodes (10-year life)
- Matching molybdenum cross hairs
- Adjustable brightness and focus
- Rubber eyecup
- Only 8 ounces

Model No. 1 — 27 mm. Kellner eyepiece.....\$46.00
Model No. 2 — 20.5 mm. Kellner eyepiece.....\$48.00



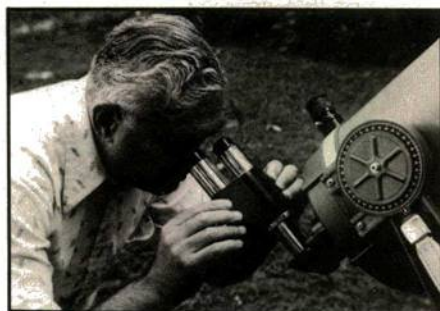
Taken by S. Hirabayashi

ANNOUNCING:

An Astronomical Breakthrough

We have been successful in reducing the cost, size, and complexity of our NEW-EST Solar Prominence Probe Mark III (3-4 Ang.). It will work not only with refractors and Schmidt-Cassegrain scopes but with NEWTONIANS as well. Limited supply, one to a customer. We also still offer our Mark I and the Famous DayStar (0.7 Ang.) filters, too. **Complete Mark III at the unheard-of price of \$198.**

AN ARRAY OF GREAT PRODUCTS To Make Your Hobby More Enjoyable



THE STEREOCULAR* ON A CELESTRON® 8

Lets you look naturally and restfully with two eyes. Gives great views of moon and planets. Some even claim to see a 3-dimensional effect.

Fits 1-1/4" drawtubes on refractors or Cassegrain-type scopes. Used with matched eyepieces. Two persons can use at the same time.

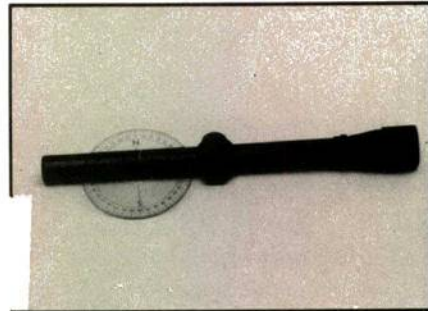
Still only \$249.00

PRECISION POLAR AXIS FINDER*

Get perfect celestial pole alignment quickly and easily every time. When the centered 4x cross hairs are set directly on Polaris, the 0.9-degree offset barrel points precisely on the pole. Novel Polaris date and time chart supplied FREE.

Celestron model 5 or 8.....\$63.00
German Equatorial model...\$57.00

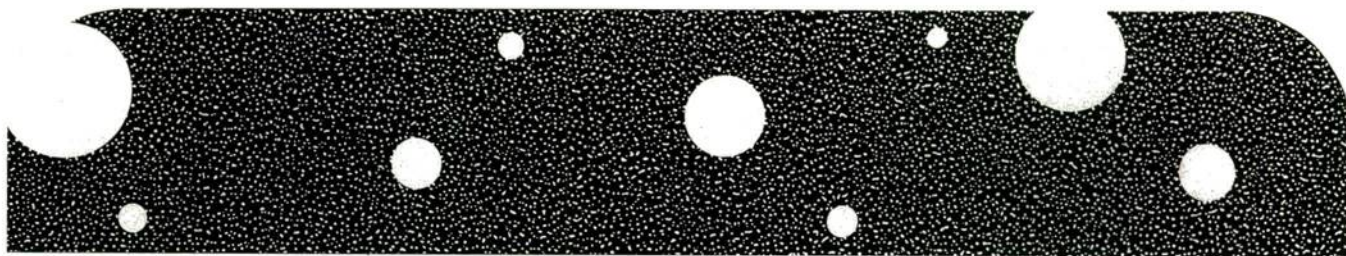
Patent Applied For



NOTICE: We are now able to supply all your telescopic needs with CELESTRON Schmidt-Cassegrains, EDMUND SCIENTIFIC reflectors; our own RFT units and custom accessories for DYNAMAX scopes of all sizes. Ask about our FREE SOLAR-SKREEN* offer concerning these products. In addition, we can supply your needs for BRANDON eyepieces, STAR-TRAP* eyepieces, LUNA-SHADE* filters, 12v D.C. inverters, ELECTRONIC EYEBALL* guiders, SUPER STAR-TRAP* DRIVE CORRECTORS, CELESTRON binoculars, and many other items. Send now for our FREE catalog.

ROGER W. TUTHILL, INC.

Box 1086A, 11 Tanglewood Lane, Mountainside, NJ 07092



STELLAR FRONTIERS

Rich Clusters of Galaxies

by
Wallace H. Tucker

One of the most persistent tales of antiquity is that of the Maelstrom, an awesome whirlpool located somewhere in the remote northern seas. It was a whirlpool of tremendous force into which the waters of the sea were sucked at ebb tide, and from which they surged at flood tide. Ancient mariners told of ships being caught up in its irresistible force, and dragged inward until all on board were destroyed in its murky unfathomable depths.

Today, astronomers offer equally astonishing reports of their observational and theoretical explorations of the vast "oceans" of space. They speak of a place in our galaxy where a black hole is crushing matter out of existence!

Farther out in remote areas of space, we encounter the counterpart of the Maelstrom — rich clusters of galaxies. In these distant places a gravitational maelstrom has been grinding away for eons — a giant whirlpool into which galaxies are drawn together. The understanding of its workings may provide the answer to some of the most perplexing riddles of modern astronomy.

In the first quarter of this century, astronomers made two of the greatest scientific discoveries of all time. They determined that our solar system was part of the Milky Way galaxy, a majestic system of 10 billion stars, and that the universe at large contains billions of similar galaxies. On a very large scale, the galaxies *appear* to be distributed uniformly both in angle around the sky and distance from us. On the other hand, small scale fluctuations in galaxy distribution do exist, and almost every galaxy in the universe is a member of a group or cluster of some size or other. Our own Milky Way is a member of the *local group*, a collection of at least 20 galaxies of different sizes and shapes.

The galaxies in the local group are contained

within a sphere having a diameter of about two million light-years. At opposite ends of the group are our Milky Way and the Andromeda nebula — large spiral galaxies that together contain about 70 percent of the mass of the local group. It is somewhat busy around Andromeda and the Milky Way, but there is a lot of empty space in the group and the chance of the large galaxies ever colliding is highly unlikely.

Over half the galaxies in the universe belong to small groups with lots of open space, such as the local group. At the other extreme are rich clusters, in which over 1,000 galaxies are packed into a space roughly the size of the local group. One rich cluster is located in the constellation Coma Berenices. Called the Coma cluster of galaxies, it is almost directly overhead in the springtime sky, about 400 million light-years away. Another well-studied cluster is known only as A2199 (or number 2199). It is about 500 million light-years from Earth! It's not on the edge of the universe (that's 20 billion light-years away, according to the latest estimate), but in the remote "northern seas" of the universe, to be sure. About 10 percent of all the galaxies in the universe are in rich clusters such as these.

Careful study has shown that in both clusters, the galaxies have swarmed together in the shape of a ball. The spherical shape must result from the balancing of random galactic motions and the mutual gravitational attraction of all the galaxies in the cluster.

But there is a problem: If we add up all the galaxies in the cluster and compute the total mass contained in them, it only amounts to between 10 and 20 per-

Rich clusters are defined as areas in which over 1,000 galaxies are packed into a small portion of space. An example of a rich cluster can be found in the constellation Coma Berenices. This photograph illustrates part of the Coma cluster at a distance of 500 million light-years. Mount Wilson and Palomar photograph.





cent of the mass needed to provide the gravitational force necessary to balance the random motions of the galaxies. On the other hand, the clusters seem to be in equilibrium, so the balance seems to hold. If the gravity of the cluster were really as weak as the count indicates, the galaxies would not be concentrated into a tight ball a few million light-years across, but would be spread irregularly over tens of millions of light-years. There are two options available here. We could assume that galaxies are continually being created in the center of the cluster to maintain the concentration of galaxies there (an assumption that few astronomers are willing to make), or we could assume that most of the mass in the cluster has yet to be discovered. But where is it? It can not be in the form of gas. X-ray observations give us a fairly accurate measurement of the amount of hot gas present: about as much mass as in the galaxies. Optical and radio observations rule out cold gas as a means for providing the missing mass. It could be in black holes, but no one has a very good explanation as to how it got there. The most likely explanation is that the missing mass is related to the overcrowded conditions of rich clusters.

Unlike the local group, there is not much space for the galaxies to move about in rich clusters, and collisions must inevitably occur. Most of the collisions are not head-on, but the cumulative effects of many grazing collisions result in equal distribution of energy among the galaxies. In other words, galaxies moving in the same gravitational force field have the same kinetic energy, or energy of motion. The kinetic energy is proportional to the mass times the square of the velocity. This means that a galaxy that is more massive than average moves much slower than average as a result of this equal distribution of energy. The speed of the massive galaxy is not enough to keep it in orbit, so it spirals inward. The acceleration of gravity speeds it up, but the dynamic friction caused by continued collisions prevents the galaxy from picking up enough speed to stabilize its orbit. It is trapped in a gravitational maelstrom of ever-increasing strength.

Eventually the gravitational forces that bind the stars to the infalling galaxy are overwhelmed by the combined gravity of the galaxies in the core of the cluster. Just as our oceans are pulled away from the shore at ebb tide by the moon, so are the stars pulled away from their parent galaxy. Eventually the descending galaxy is torn apart and its stars are captured by a large galaxy, or pair of galaxies, sitting at the center of the cluster, at the bottom of the maelstrom.

The cores of rich clusters are often made up of supergiant elliptical galaxies. These galaxies have been around for about 10 billion years, pulling the wreckage of other galaxies in toward their cores. This photograph shows the size of the supergiant elliptical galaxy, NGC-6166, as compared to M-31, the Andromeda galaxy (inset) with the scale for both objects being the same. NGC-6166 photograph by National Geographic Society - Palomar Observatory Sky Survey; M-31 photograph by E.E. Barnard.

It takes a few hundred million years for a large galaxy to drift to the center of the cluster and be destroyed by its gravitational tides. This may seem like a long time, but 100 million years is only a season in the life of a galaxy — the time it takes for a giant spiral like our Milky Way to make one revolution. Most (perhaps all) galaxies and clusters of galaxies have been around for 10 billion years. In this time a galaxy sitting at the bottom of the gravitational potential well in the center of the cluster could have grown to a colossal size by assimilating the wreckage of 100 galaxies.

This has apparently happened. Many rich clusters have supergiant elliptical galaxies in their cores. The cluster A2199 is an excellent example. The bright galaxy in the center — number 6166 in the **New General Catalog** (NGC) of galaxies — dominates the cluster. Astronomers classify galaxies such as NGC-6166 as *cD galaxies*. The "D" stands for a galaxy with a bright elliptical core surrounded by an extensive envelope, which in the case of NGC-6166 has a diameter of over two million light-years. The "c" stands for supergiant, a notation taken from stellar classifications used to indicate the huge size of the galaxies. Recent deep photographic surveys of the central regions of rich clusters suggest that the halos around cD galaxies are even greater than previously believed. They may extend outward to the edge of the cluster. If this is true, then the missing mass may have been found, hiding in quadrillions of low mass stars which have been torn from galaxies and spread throughout the cluster as part of a superhalo around a supergalaxy. These days, astronomers are spending long nights on mountaintops taking deeper and deeper plates of rich clusters, closing in — they hope — on the solution to the problem of the missing mass.

It will be very satisfying to discover the mass that holds the cluster together, but it won't be enough. There are other things which are not understood. What is at the very center of the supergiant galaxy? Could it be the entrance to another universe? Radio observations may be of some help here. Rich clusters and supergiant galaxies are known to be strong sources of radio emission. This emission must be produced by an incredible reservoir of very high energy particles. The total energy of this reservoir is comparable to the energy in the starlight produced by all of the stars in the galaxy over the entire lifetime of the galaxy.

How are the high energy particles produced? Perhaps by an explosion? What caused it? Was it one large explosion or many small ones? What is the source of all that energy?

When we are confronted in everyday life with an unknown object, we are apt to shake it, smell it, taste it, feel it, and look at it from every angle. Astronomers go through much the same process. They can use only one of the five senses, sight, but they make the most of it. They gather in as much light as possible with giant telescopes, passing it through polarimeters, spectrometers and other devices in a painstaking



ing search for clues which will open the way to understanding. One of the major advances of the last two decades has been the adaptation of the astronomer's "eye" to radio, microwave, infrared and x-radiation waves. As we know from looking at x-rays of the human body, the appearance of things can change with the wavelength of the radiation. A systematic comparison of an object's appearance at different wavelengths can often reveal connections which may lead to a breakthrough in understanding the nature of the object.

With this in mind, three scientists (Thomas Mathews, William Morgan and Maarten Schmidt) undertook an optical survey of the galaxies associated with strong radio sources. The results of their survey, published in 1964, showed that approximately half the strong radio sources are associated with supergiant elliptical galaxies which are centrally located in clusters. Many of these galaxies have a strange feature in common which may be a clue to their association with strong radio sources. The nucleus, or core, of the galaxy is complex — often consisting of several distinct nuclei. (NGC-6166 is a good example of this.) These bright multiple nuclei could represent the last stage of absorption of infalling galaxies by the supergiant galaxy. The outer parts of the galaxies have already been dispersed and added to the halo of the cD galaxy, but the galactic nuclei (because of their more compact concentration of stars) have withstood the tidal forces and retained their identity, giving the cD galaxy the appearance of a multiple yolked egg. Although this process has yet to be studied theoretically, we can speculate that eventually the nuclei will be absorbed by the massive nucleus of the cD galaxy.

What's it like inside the nucleus of a supergiant galaxy? Teeming, brilliant and raging, as 100 million or more stars captive to their own collective gravity swarm furiously with insufficient room to pass safely. Stars collide — not just in grazing collisions like

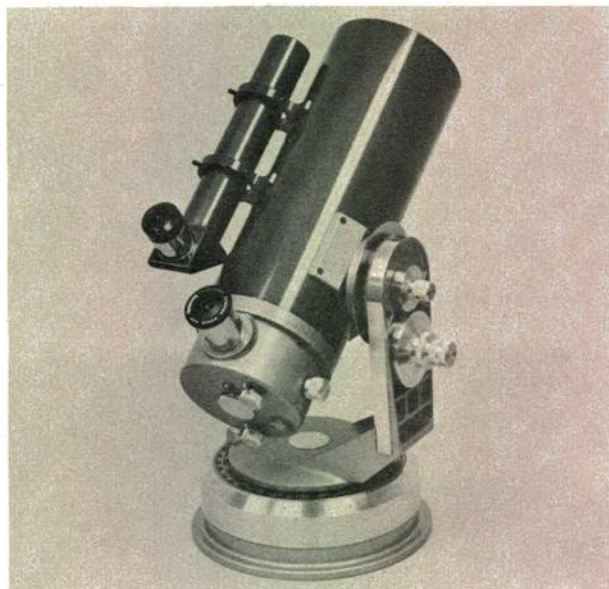
This photograph shows the multitude of galaxies in the Coma Berenices cluster, one of the richest clusters of galaxies known to man. A detailed shot of the cluster is on page 29. Hale Observatory photograph.

galaxies in a cluster, but head-on. Sometimes they bounce off one another like two billiard balls; often they stick together to form a larger star. This larger star will present a larger target to another star, so before long it will be struck again, growing even larger. This process leads to a rapid buildup of massive stars. Their fate is uncertain. Do they explode, collapse to form a black hole, or merge to form a superstar a million times more massive than the sun? The answer depends on whom you ask and when. Today, a growing number of astronomers are seriously considering the possibility that the nucleus of a supergiant galaxy contains a black hole having the mass of 100 million suns. This black hole grows at the rate of one solar mass per year as it captures nearby stars and gas. As matter swirls toward the black hole, its natural resistance to being crushed will result in the buildup of thermal, radiant and electromagnetic energy which *could* produce the observed explosive activity.

In one sense, it would be pleasing if all the processes in the cluster — formation of the cluster itself, condensation of matter into galaxies and stars, settling of galaxies to the center of the cluster and finally, disappearance of matter down the black hole — could be viewed as the work of a grand gravitational maelstrom. On the other hand, a drama is being acted out in those remote places — a drama of matter trapped by gravity, inexorably drawn toward a black hole. It has a tragic, nightmarish quality about it which is disturbing to contemplate, however afar in space and time the stage may be. 🐞

Wallace H. Tucker is senior theoretical astrophysicist for the High Energy Astrophysics Division of the Harvard-Smithsonian Center for Astrophysics. He received his Ph.D from the University of California at San Diego in 1966.

Introducing— The Quantum Series of Maksutov Cassegrain Telescopes



Available in 4-inch and 6-inch models, each instrument includes optical tube assembly with built-in star diagonal, tabletop legs, 2x Barlow lens, 16-mm. Koenig eyepiece (94x and 190x) of 80° apparent field, 30-mm. right-angle finder scope, single-arm fork mount, setting circles, slow-motion controls, electric sidereal clock

drive, electric cord, lenscap, dewcap, carrying case and instruction booklet. Delivery will commence on September 14th.

Introductory Price, effective through December 31, 1977:

Quantum 4 at **\$750.00** Quantum 6 at **\$1,250.00**

Optical Techniques, Inc., was formed a short time ago by John Schneck, former Vice-President of Questar Corporation, and Robert Richardson, who was Sales Manager of that company. Together they have a combined total of 30 years experience in the design, production, and sale of high-quality Maksutov-Cassegrain telescopes. In addition, many of their staff have wide experience with these and similar instruments.

The company was formed because they believe that the full capabilities of the Maksutov-Cassegrain telescope design have never been fully realized in an instrument that the average amateur can afford to purchase. Until now, if you wanted the advantages of the Maksutov-Cassegrain, you had either to fabricate it yourself (a very difficult and often unsuccessful venture), or you paid a very high price for a professionally made instrument. The latter situation has, in the past, prevented many from enjoying the advantages of this superb optical system.

O.T.I. completely redesigned the Maksutov-Cassegrain. Unlike previous catadioptric systems, the Quantum series of Maksutov-Cassegrains meets the goal of maximum image contrast by reason of its mere 33% central obstruction, which puts more of the light energy into the central Airy disk and keeps it out of the diffraction rings. This results in a catadioptric telescope with unmatched capability to reveal delicate low-contrast detail on the moon and planets, where definition is paramount.

For those who have an interest in deep-sky observations, the Quantum Four and Six offer a much larger diffraction-limited field of view than other currently available compound telescopes of equal aperture (9 mm. in the Four and 12 mm. in the Six). This, when coupled with the high-contrast imagery previously mentioned, allows exquisite views of subtle tonal gradations in nebulae and galaxies.

The mechanical and optical quality of our instruments equals or surpasses that of the best examples of commercially produced catadioptric Cassegrain telescopes available today. We do not employ any compromise in optical or mechanical design, and you obtain all the advantages of a true f/15 system. For additional information, please write for our descriptive literature.

Western Representative:

Leo C. Henzl, Jr.
P. O. Box 6038
Rolling Hills, California 90274
213-541-4331

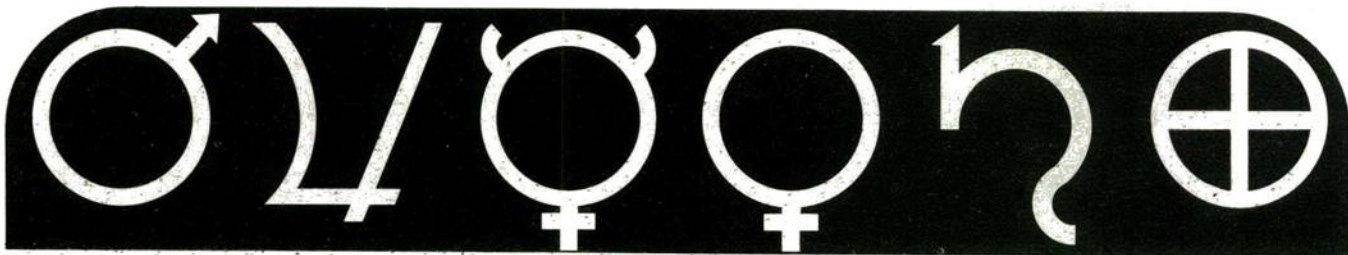
OPTICAL TECHNIQUES, INC.

P. O. Box 275, Newtown, Pa. 18940

(215) 968-4739

Midwestern Representative:

James P. Skinner
3838 West 107th Place
Chicago, Illinois 60655
312-779-8945



SKY ALMANAC

U.S. Gets Partial Eclipse

All the bright planets are well placed for observation this month, and are easily visible in the morning sky. As the outer planets approach their opposition dates (which they will reach late this year and in early 1978), they are gradually becoming visible earlier in

the night. Choose a few mornings this month to get up a little while before dawn and take a look at the planets before sunrise. You won't regret it!

Venus

Still the brightest object in the east-

ern sky during the hours before sunrise, Venus shines at magnitude -3.4 during October. It is slowly drawing nearer the sun and will reach conjunction in January, so the planet now rises only two hours before it. But you can't miss Venus if you face east any morning this month; it far outshines all the other planets and stars.

On the mornings of the 10th and 11th, Venus will be located not far from the waning crescent moon. Since the moon is new on Oct. 12, it will present a very thin crescent phase on both dates. This is one time when it will help to locate another object (Venus) before you try finding the moon, instead of the other way around!

Through the telescope, Venus shows a very fat gibbous, almost full, phase. Its apparent diameter shrinks during October from 11.7 to 10.7 seconds of arc, while its distance from Earth increases from 134 million miles (215 million km) to 145 million miles (234 million km).

Mars

During the next few months, before it is at opposition in January, Mars will increase rapidly in brightness as it speeds past Earth. Currently its magnitude is about 0.6, and it will brighten by more than a full magnitude by opposition.

Mars moves through Gemini into Cancer during the month. Around the 16th, it will be lined up with Castor and Pollux — giving us (temporarily, at least) a set of triplets instead of twins in the sky! The red planet rises shortly before midnight and can easily be found throughout the latter half of the night. Novice planetgazers are frequently startled by its pronounced red hue; Mars is certainly the reddest object in the sky — even more so than the

October Satellites of Jupiter
2:00 a.m. EDT, 11:00 p.m. PDT

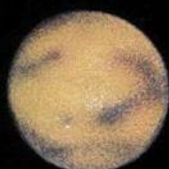
1	24103	• • • • •	16	4201	• • • • •
2	30214	• • • • •	17	43102	• • • • •
3	30124	• • • • •	18	3240	• • • • •
4	32104	• • • • •	19	23014	• • • • •
5	23014	• • • • •	20	10234	• • • • •
6	10234	• • • • •	21	01234	• • • • •
7	02134	• • • • •	22	21034	• • • • •
8	21034	• • • • •	23	20314	• • • • •
9	23014	• • • • •	24	31024	• • • • •
10	3402	• • • • •	25	304	• • • • •
11	34210	• • • • •	26	3204	• • • • •
12	42301	• • • • •	27	41023	• • • • •
13	41023	• • • • •	28	40123	• • • • •
14	40213	• • • • •	29	42103	• • • • •
15	42103	• • • • •	30	42031	• • • • •
			31	43102	• • • • •

The four major satellites of Jupiter orbit the planet in periods ranging from less than two days to 17 days. You can see them change position from one night to the next; their motions are often evident after only a few hours' observation. You only need a small telescope to detect all four, and you can frequently make out several in rigidly held (or tripod mounted) binoculars. This table shows the approximate positions of the moons at about 3 a.m. EDT on the mornings indicated. The first column on the left shows the date; the second column identifies the moons by their positions relative to Jupiter's disk (1 = Io, 2 = Europa, 3 = Ganymede, 4 = Callisto, 0 = Jupiter's disk). The third column gives the satellites' positions as they appear through a telescope. The orientation of the satellite is given with south up as seen through a standard inverting telescope.

The Omega nebula (M-17), located near the northern border of Sagittarius, is one of many nebulae found in the summer Milky Way. This photograph is a two hour exposure on High Speed Ektachrome, made with a 14 inch Schmidt-Cassegrain at f/5.6. Photograph by Ben Mayer.



Planet Finder

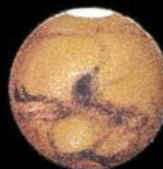


(A) Mercury

Oct. 1
R.A. 11h47m
Dec. +3°24'
Mag. -1.0

(B) Mercury

Oct. 15
R.A. 13h17m
Dec. -6°56'
Mag. -1.1

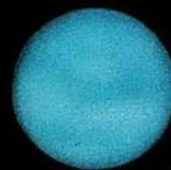


(M) Mars

Oct. 1 15
R.A. 7h18m 7h48m
Dec. +22°53' +22°05'
Mag. +0.8 +0.6

Oct. 1 15
R.A. 14h29m 14h51m
Dec. -10°14' -12°19'
Mag. +8.9 +9.0

(C) Ceres



(N) Neptune

Oct. 15
R.A. 16h51m
Dec. -21°03'
Mag. +7.7



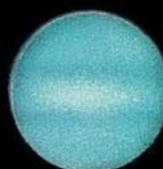
SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.



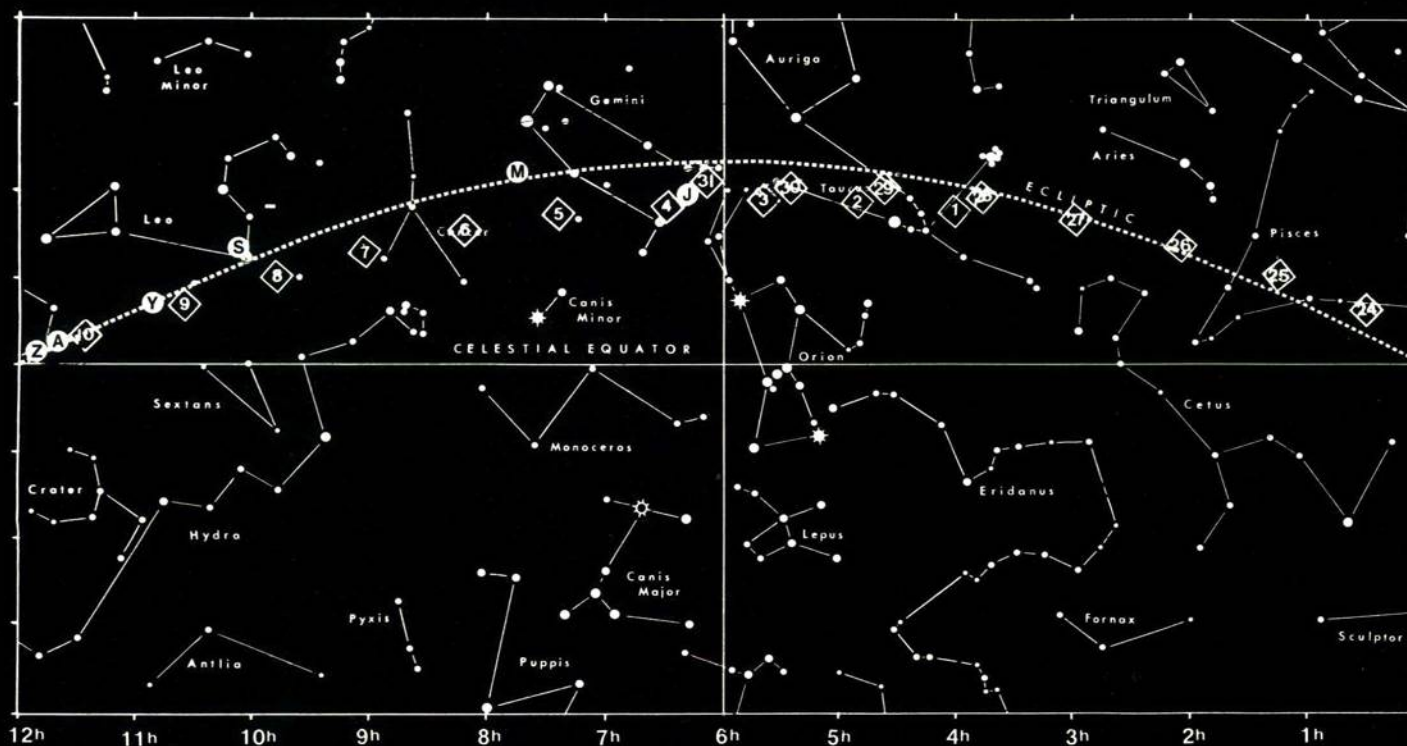
(S) Saturn

Oct. 1 15
R.A. 9h56m 10h01m
Dec. +13°45' +16°19'
Mag. +0.8 +0.8



(U) Uranus

Oct. 15
R.A. 14h34m
Dec. -14°43'
Mag. +5.7



The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

October 1977



(V) Vesta

Oct.	1	15
R.A.	12h08m	12h34m
Dec.	+4°17'	+1°38'
Mag.	+8.6	+8.5



(J) Jupiter

Oct.	1	15
R.A.	6h23m	6h26m
Dec.	+22°57'	+22°56'
Mag.	-1.9	-2.0



(Y) Venus

Oct.	1	
R.A.	10h53m	
Dec.	+8°23'	
Mag.	-3.4	

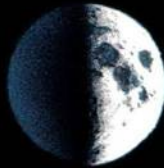
(Z) Venus

Oct.	15	
R.A.	11h57m	
Dec.	+1°54'	
Mag.	-3.4	



(P) Pluto

Oct.	15	
R.A.	13h17m	
Dec.	+9°42'	
Mag.	+14	



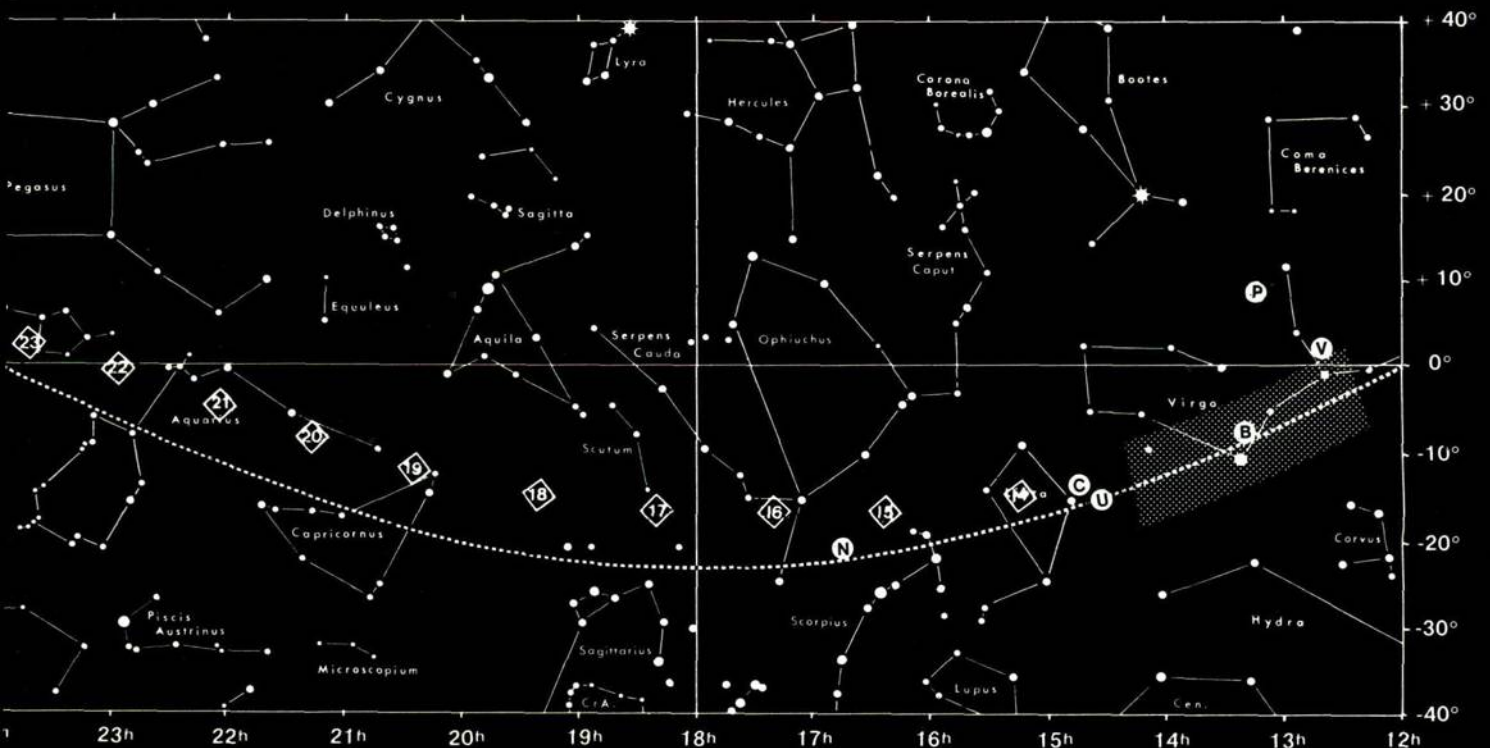
First Quarter
October 19



Full Moon
October 26



Last Quarter
October 5



measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.



red supergiant stars like Betelgeuse — and its color makes identification that much easier.

Mars lies six degrees north of the last quarter moon on the morning of Oct. 6. Its apparent angular diameter grows this month from 7.1 to 8.5 seconds of arc, and its distance from Earth shrinks from 122 million miles (197 million km) to 102 million miles (164 million km). Mars is now closer to Earth than Venus is.

Jupiter

Jupiter is located in the constellation Gemini this month, a short distance southwest of the stars Castor and Pollux. It rises about 10 p.m. and by dawn has already passed the meridian. At magnitude -2.0, Jupiter is brighter than anything in its vicinity, and you should have no trouble spotting it.

On the 24th, Jupiter is stationary; after that date, it begins moving retrograde. In other words, as Earth in its

Two conjunctions highlighted planetary observation during July. Left: Mercury and Saturn, only a fraction of a degree apart on the evening of July 19, were photographed through the Dynamax 8 of the St. Charles Parish Planetarium at Luling, La., only seconds before the planets were engulfed by a cloud cover. This is a one second exposure on Ektachrome 200. Right: Turning to the morning sky, Jupiter, Venus and Mars were all located in Taurus on July 30. Jupiter and Venus were in close conjunction (Venus being the brighter), while Mars was near Aldebaran in the Hyades several degrees west. This 10 second exposure on Ektachrome 200 was made with a 55mm lens at f/1.7. Photographs by James R. Westlake Jr.

orbit "catches up" to Jupiter, moving more slowly, Jupiter appears to stop moving eastward, stand still, and then begin moving west for equal amounts of time on either side of its opposition date.

The last quarter moon is a few degrees southeast of Jupiter on the morning of Oct. 5. The planet's angular diameter increases from 37 to 40 seconds of arc during the month, as its distance from Earth decreases from 462 million miles (742 million km) to 421 million miles (677 million km).

Saturn

Saturn is located in the constellation Leo, near the bright star Regulus. It

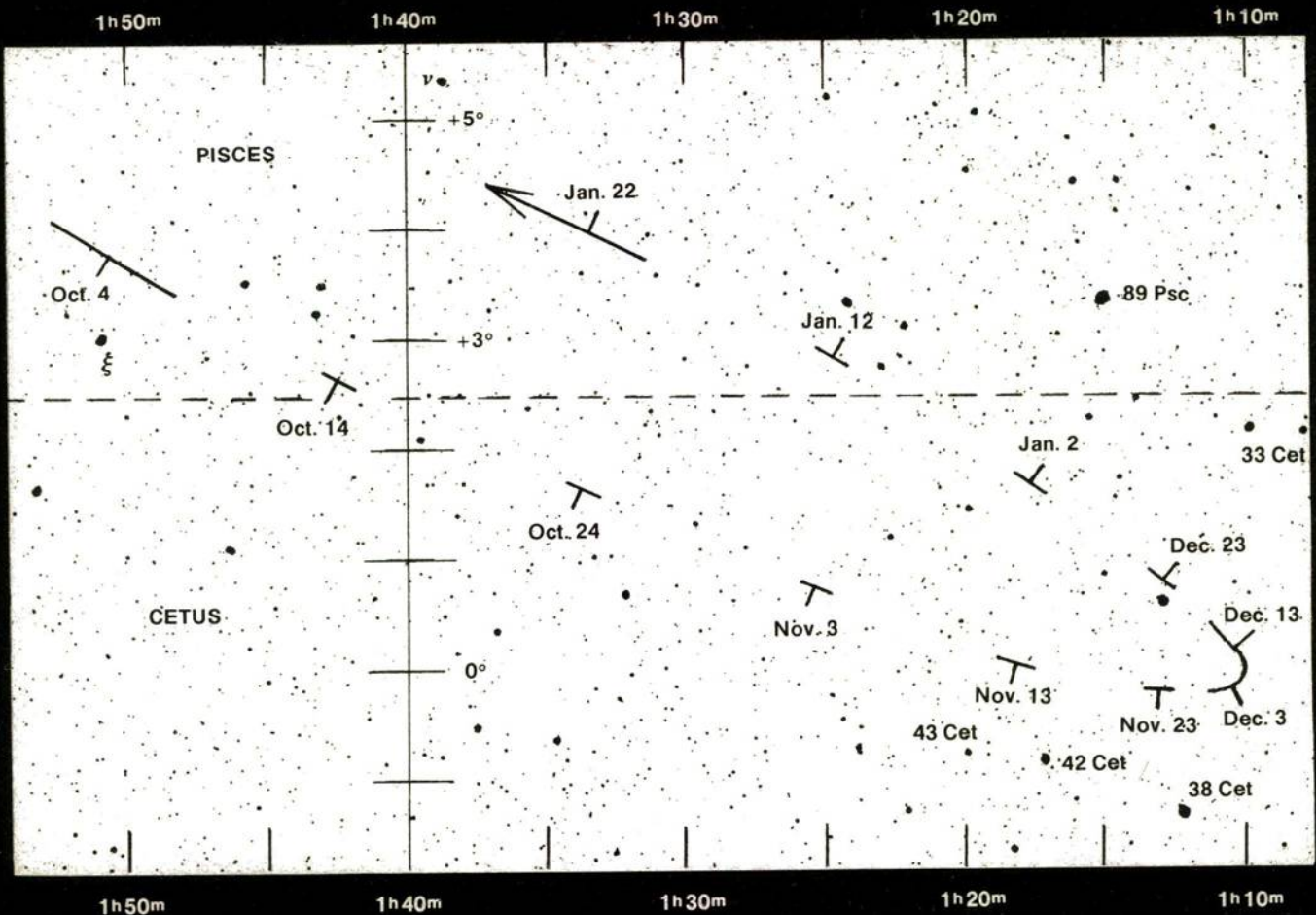
Satellite Shadows on Jupiter

Date	Satellite	Transit Begins (EDT)	Transit Ends (EDT)
Oct. 2	1	2:30 a.m.	4:49 a.m.
3	1	9:07 p.m.	11:17 p.m.
9	1	4:32 a.m.	6:42 a.m.
10	2	7:41 p.m.	10:18 p.m.
10-11	1	11:00 p.m.	1:11 a.m.
15-16	3	10:40 p.m.	1:26 a.m.
17-18	2	10:17 p.m.	12:55 a.m.
18	1	12:53 a.m.	3:04 a.m.
23	3	2:38 a.m.	5:26 a.m.
25	2	12:53 a.m.	3:32 a.m.
25	1	2:47 a.m.	4:58 a.m.
26	1	9:15 p.m.	11:26 p.m.

1 = Io
2 = Europa

3 = Ganymede
4 = Callisto

Opposition of Asteroid 5 Astraea



Asteroid 5 Astraea reaches opposition on Oct. 20; its visual magnitude is 10.5, and it will lie at a distance of about 158 million miles from Earth. The map above shows Astraea's path through Pisces and Cetus during the latter part of 1977 and early 1978. The star field is taken from Hans Vehrenberg's *Photographic Star Atlas* (plates 197 and 198), and has been reproduced with Dr. Vehrenberg's permission. For more information on observing asteroids, see the June 1977 *Gazer's Gazette*. Map by Jay Gunter.

rises about four hours before the sun and shines at magnitude 0.8 during most of October. Saturn is situated a few degrees north of the crescent moon on the morning of the 9th. Its apparent angular diameter increases very slightly from 15 to 15.6 seconds of arc this month, while it slowly draws nearer Earth; its distance changes from 922 million miles (1,483 million km) to 885 million miles (1,423 million km).

An event of special interest will occur on Oct. 3, when Saturn occults (passes in front of) the eighth magnitude star SAO-98871. This rare occultation will take place very near the time of sunrise for most observers, and you probably won't be able to witness both disappearance and reappearance—just one or the

other, depending on your location. Observers on the east coast should be able to see Saturn cover the star at about 5:50 a.m. EDT; it will reappear after sunrise. Observers in the central United States, however, can see the star reappear from behind Saturn at 5:50 a.m. CDT (one hour later), but will miss disappearance because Saturn either will not have risen or will be too low in the sky. Remember that there will be a great contrast between the first magnitude planet and the eighth magnitude star, and the light of the latter might be drowned out by the planet in smaller instruments. Be sure also to watch the planet for as long a time as you can before the actual occultation; you may see the rings pass in front of the star too. If you're lucky enough to see this, try to observe the star shining through the rings (which, not being one solid body but millions of tiny ones, should be fairly transparent).

Mercury

Mercury is too near the sun to be seen this month. It is in superior conjunction (on the other side of the sun from Earth), on Oct. 18.

Meteors

The Orionid meteor shower reaches

its peak on the morning of Oct. 21. The shower (so-called because its radiant point is situated in the constellation Orion) is one of the more reliable ones currently visible to observers on Earth, and this year's conditions should be good. The first quarter moon will have set by midnight, leaving the hours between midnight and dawn (always the best ones for observing showers) clear of its influence. You can expect to see about 25 fast moving meteors per hour at the shower's peak.

Solar Eclipse

Residents of North America (except for northernmost Canada) will be able to see a partial eclipse of the sun on Oct. 12. This eclipse is actually a total solar eclipse, but the path of totality runs through the Pacific Ocean for almost its entire length, entering South America near its end. People in Colombia will see totality near sunset. In the U.S., the farther south and west you live, the greater the amount of sun that will be blocked out. West coast residents will experience mid eclipse at about noon, while the eclipse occurs later in the afternoon for observers farther east. Photographs of the eclipse—with or without foreground objects—are, of course, welcome at ASTRONOMY. ☾

Meade Instruments: fastest, delivery in the West... or East

As America's number one supplier of telescope accessories, our watchword is **service**. Whether placed by phone or mail, your order is shipped by First Class Mail or United Parcel Service within 24 hours. Our inventory of eyepieces, filters, camera adapters, viewfinders, and other telescope parts is the largest in America. Ready for the fastest delivery in the West... or East.

MEADE Research-Grade Eyepieces

A few words from our customers...

I am not only pleased but rather astounded by the optical perfection of your Research-Grade eyepieces.

Peter Armato Sparks, Nevada

My son made me a present of one of your Research-Grade 10.5mm oculars. It has performed magnificently, and far ahead of any other eyepiece I have ever used, even in the besodden atmosphere we have here in the Ohio Valley.

Donald J. Smith Shadyside, Ohio

I am now using a Research-Grade Erfle 20mm purchased from your firm recently on my Celestron 14 and find the ocular is all that you claim and more. It reveals delicate color contrasts on Saturn superbly, as well as globular clusters, nebulae, and double stars.

Norman J. Boisclair Rensselaer, New York

I appreciate the fast shipment of the 20mm Research-Grade Erfle, which was in my hands 4 days after I mailed the order! I would also like to say that the eyepiece is the finest I have ever used, borrowed or seen, and I have seen many in the 15 years I have been an amateur. In the future I intend to convert my battery of eyepieces to Meade Research-Grade orthoscopes. The sooner the better.

Jim Schultz Lyons, Colorado

Let me mention how pleased I am with your products and the very prompt service I have received. I am especially excited with your Research-Grade 20mm Erfle. Its incredible field of view and flatness of field make it perfect for my variable star work. It is truly breathtaking with deep-sky objects. The real surprise came when coupled with your Research-Grade 2X Telenegative Amplifier... truly a fine optical achievement.

James L. Ferreira Fremont, California

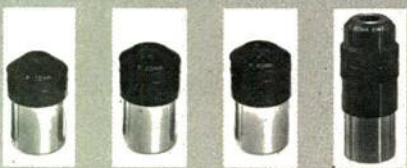
Series 1 Orthoscopic Eyepieces (1 1/4" and .965" O.D.) - Classical 4-element design, 45° field, available in 8 focal lengths. See Items #2, 3.



Research-Grade Orthoscopic Eyepieces (1 1/4" O.D.) - Multi-coated, 4-element, parfocal. The finest astronomical eyepieces obtainable. See Item #4.



Series 1 Kellner Eyepieces (1 1/4" O.D.) - Fine performance at a moderate price. Two 40mm wide-field models available. See Items #5, 6.



Illuminated Reticle Eyepiece - For precise photographic guiding and accurate measurement of angular distances. See Item #14.



2x-3x Telenegative Amplifiers - The world's finest Barlow lenses, 26mm clear aperture, 1 1/4" O.D. See Items #16, 17.



Rack-and-Pinion Focusers - Three superbly engineered focusers. Thousands in use by amateurs everywhere. See Items #21, 22, 23.



Camera Adapters - Precision machined adapters for quick attachment of cameras to your telescope. See Item #20.



Zoom Orthoscopic Eyepiece - 8.4-21mm (1 1/4" O.D.). See Item #8.



2" O.D. Eyepieces - See Items #10, 11.



8 x 50 Right-Angle Viewfinder - With new Kellner 30mm Extra-Wide-Field crosshair eyepiece. See Item #31.



PRODUCT DATA

1 - PHOTO-VISUAL COLOR FILTERS - Top quality optical glass, dyed in the mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1-1/4" "Series 1" and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color:

#8 Light Yellow - #11 Yellow-Green - #12 Yellow - #21 Orange - #23A Light Red - #25A Red - #47 Violet - #58 Green - #80A Medium Blue - Polarizer (30% transmission) Each Filter...\$4.95 ppd. - Set of any 6...\$28.50 ppd. - Full set of 10...\$46.50 ppd.

2 - Series 1 ORTHOSCOPIC EYEPIECES (1-1/4" or .965" O.D.) - These Meade eyepieces are the largest selling orthoscopes in the world. Classical 4-element design, 45° field, fully coated, with precise corrections for color and field flatness. All 1-1/4" barrels are threaded to accept our photo-visual filters directly. Focal lengths: 4, 5, 6, 7, 9, 12.5, 18, 25mm - Each...\$17.95 ppd.

3 - Series 1 PARFOCAL ORTHOSCOPIC EYEPIECES (1-1/4" O.D.) - As in (2) but parfocalized in all 8 focal lengths. Each...\$19.25 ppd. - Set of any 4...\$72.95 ppd. Set of any 5...\$90.00 ppd. - Additional eyepieces: each...\$18.00 ppd.

4 - RESEARCH-GRADE ORTHOSCOPIC EYEPIECES with Multi-Coated, Parfocal Optics (1-1/4" O.D.) - Acclaimed by amateur and professional astronomers everywhere to be the world's finest eyepieces. These 4-element systems are unsurpassed in resolution, color correction, and flatness of field. Air-to-glass surfaces are 5-layer multi-coated for maximum image contrast and light transmission. 45° field. Precisely parfocal. Barrels are threaded to accept our filters directly. Focal lengths: 4, 7, 10.5, 16.8, 28mm each...\$29.95 ppd. - Set of any 4...\$112.50 ppd. Set of any 4 plus Res. Gr. Erfle 20mm...\$137.50 ppd. - Full set of 5 Res. Gr. Orthoscopes plus Res. Gr. Erfle 20mm...\$165.00 ppd. (Sets of 4, 5, or 6 eyepieces are shipped in fitted carrying case (see (27) at no additional charge).

RESEARCH-GRADE ERFLE 20mm (1-1/4" O.D.) - Parfocalized with our Research-Grade Orthoscopes and 5-layer multi-coated. Apparent field in excess of 75° for breathtaking wide-angle observations. Barrel accepts our filters directly. \$36.50 ppd.

5 - Series 1 KELLNER EYEPIECES (1-1/4" O.D.) - Highly corrected, 3-element design, fully coated. The best in moderately priced eyepieces. Barrels threaded for our filters. Focal lengths: 6, 12, 25mm each...\$12.50 ppd. - 40mm Wide Field...\$14.50 ppd.

6 - KELLNER 40mm EXTRA-WIDE-FIELD (1-1/4" O.D.) - Yields widest field obtainable in 1-1/4" O.D. Enlarged field lens and special field-flattening optics with long eye relief. Barrel accepts our filters...\$22.75 ppd.

7 - Series 1 ERFLE 20mm (1-1/4" O.D.) - An advanced 5-element system with fully coated, color corrected optics. Wide 65° field. Barrel accepts our filters. \$23.95 ppd.

8 - ZOOM ORTHOSCOPIC EYEPIECE (1-1/4" O.D.) - Zooms instantly from 8.4mm to 21mm, with excellent image corrections at all powers. Wide 50° field at 8.4mm. Fully coated optics...\$32.95 ppd. - Filter adapter #004: couples our filters to above eyepiece...\$1.00 ppd.

9 - ZOOM KELLNER EYEPIECE (.965" O.D.) - Fine 4-element design. Zoom range 7.5mm-22.5mm. Fully coated optics...\$24.95 ppd.

SUPER-WIDE-FIELD EYEPIECES (2" O.D.) - Premium-quality wide-field eyepieces for 2" focusers. The ultimate in rich-field performance. Fully coated.

10 - ERFLE 32mm (2" O.D.) - Sophisticated 5-element optical system. Wide, flat 65° field...\$67.50 ppd.

11 - KELLNER 60mm (2" O.D.) - Low power, long eye relief. Ideal for deep-space observations...\$42.50 ppd.

12 - ERFLE 32mm (1-1/4" O.D.) - As in (10), but with standard 1-1/4" barrel, threaded for our filters. 60° field...\$67.50.

13 - .965" EYEPIECES - (phone, or request catalog, for details).

14 - ILLUMINATED RETICLE GUIDING EYEPIECE (1-1/4" or .965" O.D.) - For professional-level photographic guiding. Kellner 12mm optical system, with precisely focusable 4-line glass reticle. Remote brightness control and 3 ft. cable. (Extension cables available) Complete...\$37.50 ppd.

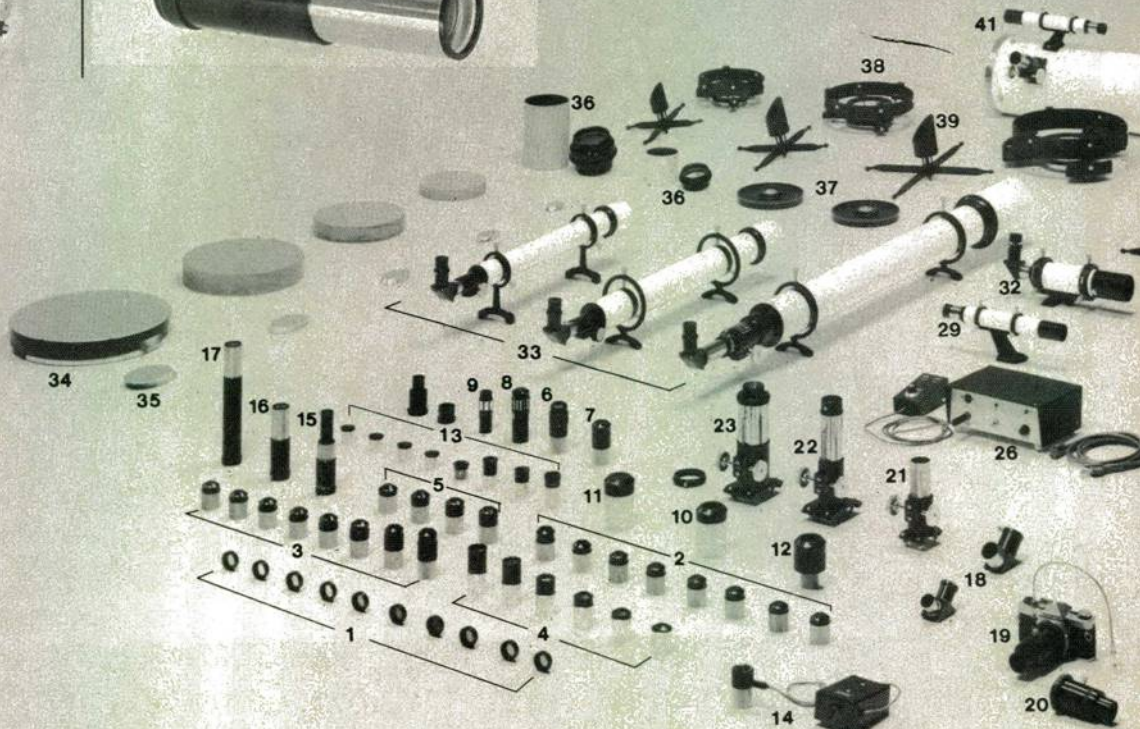
Micrometer Reticle - Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle...\$11.95 ppd.

15 - 2X ACHROMATIC BARLOW LENS (1-1/4" O.D.) - A high resolution, coated, negative achromat with excellent corrections for spherical and chromatic aberrations. \$18.75 ppd.

16, 17 - 2X AND 3X TELENEGATIVE AMPLIFIERS (1-1/4" O.D.) - The world's finest Barlow lenses. Full 26mm clear aperture; with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio. Fully coated. (16) 2X Model 122...\$29.50 ppd. (17) 3X Model 123...\$32.50 ppd. - Combination 2X and 3X Model 124...\$39.50 ppd.

18 - DIAGONAL PRISMS - Quality, right-angle prisms, fully coated, 1-1/4" O.D....\$14.95 ppd. - .965" O.D....\$10.95 ppd.

19 - OLYMPUS OM-1 ASTROCAMERA - One of the world's great astrocameras. (Phone or request catalog for details)...From \$229.50.



20 - DELUXE CAMERA ADAPTERS - Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum. All units permit both eyepiece projection and first (prime) focus photography. Specify either .965" or 1-1/4" focuser. (If for Celestron, please specify.) All 1-1/4" units are threaded for our filters. Pentax, Praktica, Yashica, Mamiya...\$15.95 ppd. - Exakta, Nikon, Canon, Minolta, Miranda, Konica...\$23.95 ppd. - Olympus OM-1...\$24.95 ppd.

RACK-AND-PINION FOCUSERS - Precision metal construction. All 3 models include helical-cut rack for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1-1/4" eyepiece holders. Each focuser is guaranteed to be the finest obtainable in its class.

21 - Model #67 - Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value...\$14.75 ppd.

22 - Model #640 - A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications...\$21.75 ppd.

23 - Model #680 - Our finest focuser. Accepts both 1-1/4" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes...\$29.95 ppd.

VARIABLE FREQUENCY DRIVE CORRECTORS - Quality, temperature compensated circuitry for precise electronic guiding. Each model will drive telescopes to 14" aperture. 20 ft. battery cables, instructions included.

24 - Model #24 - Uses 12v. D.C. Frequency variable between 50-70Hz with knob attached to power box. An excellent value...\$49.50 ppd.

25 - Model #29 - Uses 12v. D.C. Remote control box with fast-slow buttons and variable center frequency dial for tracking at solar, lunar, or planetary rates...\$62.50 ppd.

26 - Model #33 - Uses 12v. D.C. or 110v. A.C. Other features identical to Model 29...\$89.50 ppd.

ACCESSORY CASES - Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. For either 1-1/4" or .965" accessories. Die-cut foam lining.

27 - Model #51 - 7" x 8-1/2"...\$7.95 ppd.

28 - Model #54 - 8" x 12"...\$10.95 ppd.

VIEWFINDERS - Each with coated, achromatic objective and crosshair eyepiece.

29 - 6 x 30mm: Fine, 4° wide-field finder. Thousands now in use. 2-ring bracket included...\$14.75 ppd.

30 - 8 x 50mm: Large 50mm aperture. Ke30mm Extra-Wide-Field crosshair eyepiece. Sharp, brilliant images...\$25.95 ppd. - Brackets: \$7.95/Pr.

31 - 8 x 50mm Right-Angle - 50mm aperture, for both straight-through and right-angle viewing. Prism included...\$30.95 ppd. - Brackets: \$7.95/Pr.

32 - 8 x 50mm Right-Angle - As above, but with bracket for Celestron 8...\$42.50 ppd.

33 - PHOTO-GUIDE TELESCOPES - (Phone or request catalog for details.)

2"...\$39.50 - **2-1/4"...**\$65.00 - **3-1"...**\$138.00

34 - PARABOLIC PRIMARY MIRRORS - Professional quality hand figured Pyrex mirrors, aluminized and quartz overcoated. Each mirror is guaranteed to reach all theoretical limits of performance. 6" 1/8"...\$49.95 ppd. - 10" 1/6"...\$134.95 ppd.

8" 1/6 or 1/7.5...\$79.95 ppd. - **12-1/2" 1/6...**\$239.95 ppd.

35 - ELLIPTICAL SECONDARIES - For optimum performance with any primary mirrors. Aluminized, overcoated. As optically flat as master opticians can make them. Minor axis sizes shown, postpaid: 1.30"...\$9.00 - 1.52"...\$12.50 - 1.83"...\$14.50 - 2.14"...\$17.50 - 2.60"...\$21.00

36 - OBJECTIVE LENSES - As used in Meade guide telescopes and equatorial refractors. Air-spaced, achromatic, fully coated. Mounted in machined, threaded dewcap and dustcap included. 2" 1/12"...\$19.50 ppd. - 2-1/4" 1/15"...\$34.50 ppd. - 3-1" 1/15"...\$74.50 ppd.

37 - SETTING CIRCLES - Die-cast aluminum, 6" diameter. Machine engraved. Precision guaranteed. Standard 1-1/2" bore...\$35.00/pr. Other bores (from 1/4" to 2") add \$1.50 per circle.

38, 39 - MIRROR CELLS AND SPIDERS/DIAGONAL HOLDERS are available to fit the tubing below. Phone, or request catalog, for details.

40 - FIBERLITE TELESCOPE TUBES - 20% more rigid, yet 40% lighter, than pure fiberglass, with low thermal conductivity. Polished end rings available at nominal cost. Partial price list: 7" I.D. x 50"...\$36.00 - 9-1/4" I.D. x 60"...\$49.50

12-3/8" I.D. x 62"...\$68.00 - **12-3/8" I.D. x 72"...**\$76.00

Packing charge: 7" and 9-1/4" tubes - \$4.00; 12-3/8" tubes - \$7.00

COMPLETE OPTICAL TUBE ASSEMBLIES - Fully Assembled. Each assembly includes the premium quality Meade components described above: Fiberlite tube with end rings, primary mirror and cell, spider and secondary mirror, Model #67

Focuser, 6 x 30mm viewfinder. Shipping charges collect.

41 - 6" 1/8 tube assembly...\$144.95

42 - 8" 1/6 tube assembly...\$189.95

Packing charge on tube assemblies...\$6.00

MEADE EQUATORIAL REFRACTORS - Whether beginning or serious amateur, one of these superb instruments will fit your observing requirements. Phone or request catalog for details.

43 - Model #291: 2.4" Equatorial Refractor...\$195.00

44 - Model #300: 3.1" Equatorial Refractor...\$325.00

45 - Models #420 - #440: 4" Equatorial and Photo-Equatorial Refractors, available with guide telescope, illuminated reticle eyepiece, motor drive, frequency corrector, astromer. From \$1175.00

Equatorial Mounts - Each includes complete mount, circles, 2 cables, hardwood tripod. Mount for Model #291...\$95.00 - Mount for Model #300...\$157.00

46 - 20 x 80mm ASTRONOMICAL BINOCULARS - Coated optics. Magnificent for deep-space observing...\$127.50 ppd.

Bushnell Tripod: fully adjustable...\$49.50 ppd.

MEADE INSTRUMENTS

721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281

MAIL ORDERS: Circle numbers for items desired and write your specific requirements on a separate sheet—or use the order form which accompanies our catalog.

1	2	3	4	5	6	7	8	9	10	11	12
13	14	15	16	17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45	46		

PAYMENT: Personal or bank check, money order, or credit card (BankAmericard or Master Charge)

TELEPHONE ORDERS: accepted with payment either COD or credit card (we do not accept collect calls).

SHIPMENT: All orders are processed for shipment within 24 hours of receipt.

FOREIGN ORDERS: Add 20% to cover Air Parcel Post charges—any excess will be refunded. Payment must be made by bank check in U.S.

COMPLETE CATALOG 77-C — \$1.00 (Catalog free with any order)

Method of Payment ☐ Check or Money Order ☐ BankAmericard ☐ Master Charge

Card No. _____ Expiration Date / /

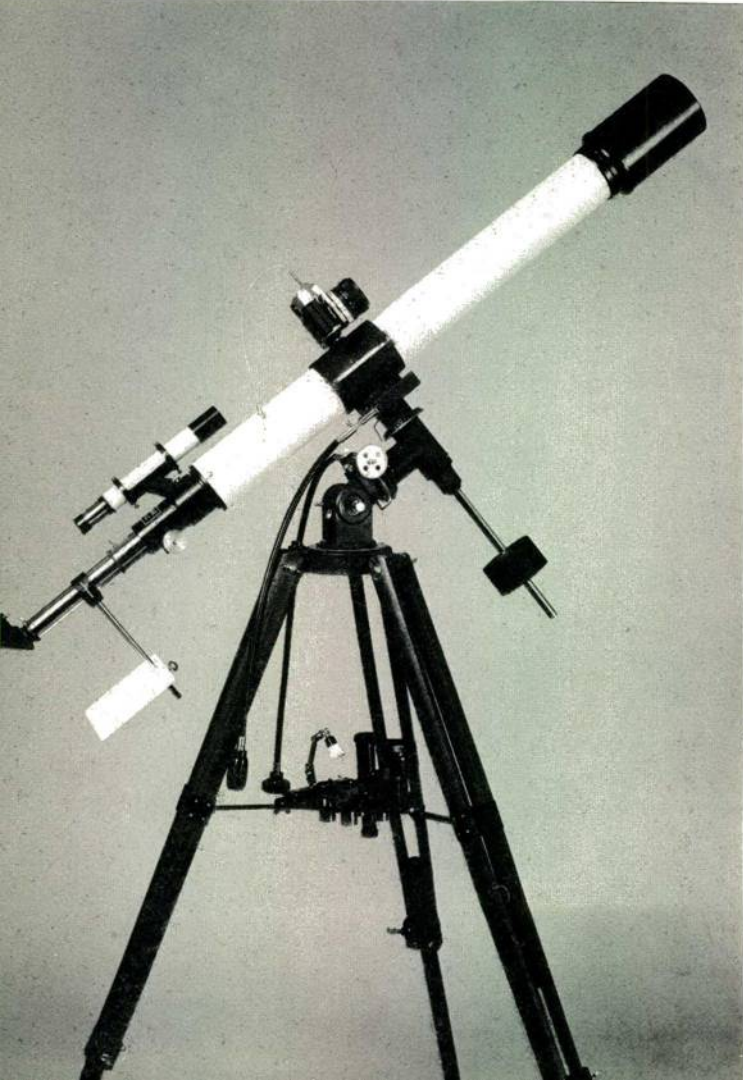
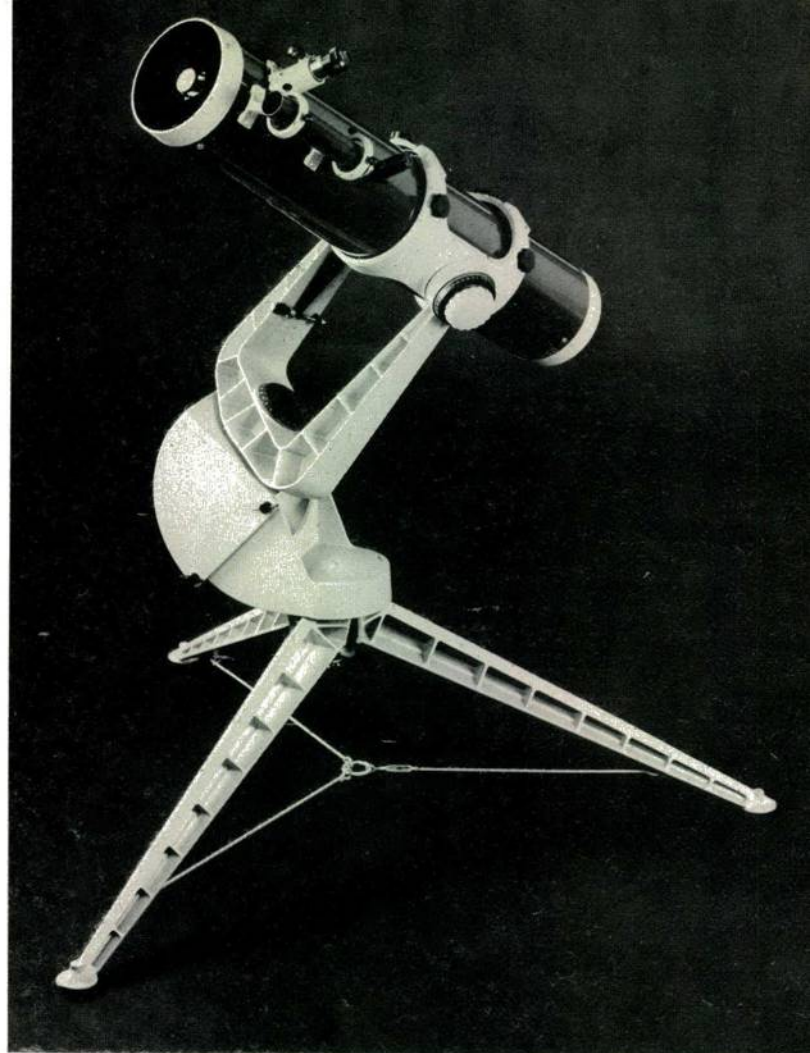
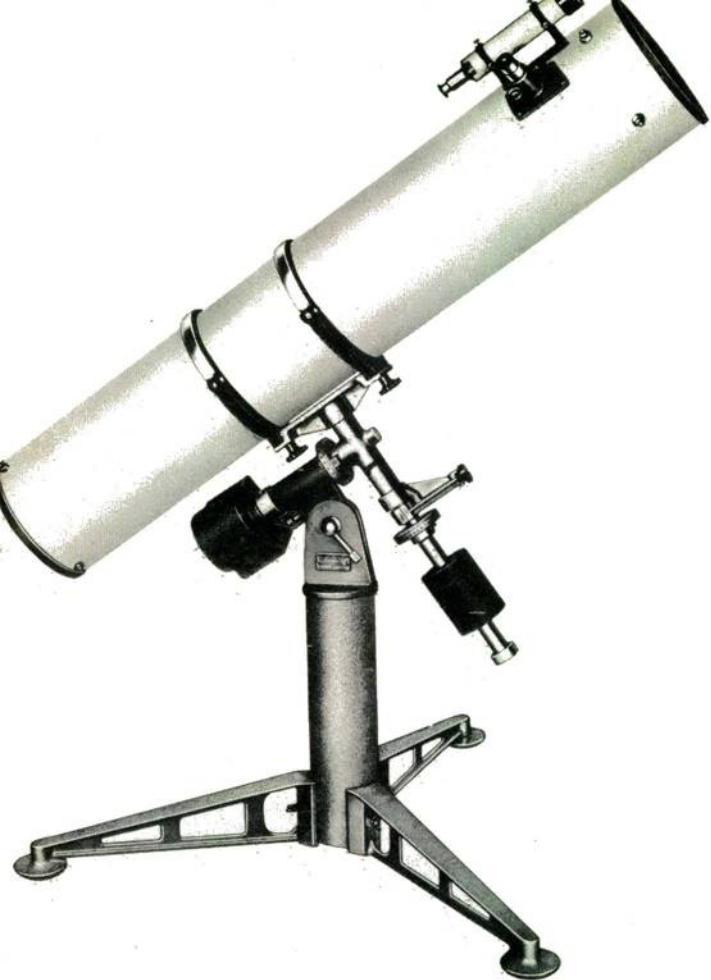
Name _____

Address _____

City _____ State _____ Zip _____

MEADE INSTRUMENTS

721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281





EQUIPMENT ATLAS

1977 Buyers' Guide to Small Telescopes

Perhaps the most important, complex — and rewarding — decision you'll ever have to make once you get started in astronomy as a hobby is the selection of your telescope. While you can enjoy the wonder and beauty of the night sky with the unaided eye and binoculars, true exploration of the heavens requires an astronomical telescope — one that is optically and mechanically sound, is priced within a range you can afford, and which suits *your* needs as an observer. Once you make the right choice, your instrument can provide a lifetime of use and pleasure.

ASTRONOMY presents here a simplified guide to telescope buying, based on tried and proven instruments and manufacturers. This article, which originally appeared in our October 1975 issue, has been revised and updated to bring you the most accurate information possible. Our discussion will be confined to the sizes of telescopes that are practical for most observers. Approximate current prices (or price ranges) are given for each type of instrument — as well as size and make — together with other useful information that may help you select a particular model. Aperture range is between 60mm (the common 2.4 inch refractor) and eight inches.

The three basic types of telescope are the *refractor* (lens type), the *reflector* (mirror type) and the *catadioptric* (compound lens/mirror system). We'll discuss the main features of each type, how they work, and what you can expect from them in regard to both performance and cost.

Refractors

The basic design of the refracting telescope has been with us for nearly four centuries — which

Telescopes come in a variety of types, sizes and mounts. Observer needs vary, so particular attention should be paid to what each manufacturer has to offer. Requests for further information should be directed to the manufacturer. Top left: Criterion Manufacturing Co. offers this eight inch Newtonian, RV-8 Dynascope on an equatorial mount. Top right: Edmund Scientific Co. recently introduced this six inch Newtonian reflector on a foldable equatorial mounting. Bottom left: Meade Instrument Co. manufactures this 3.1 inch refractor on an equatorial mount. Bottom right: Unitron Instruments recently released this new design in telescopes, a compact three inch refractor.

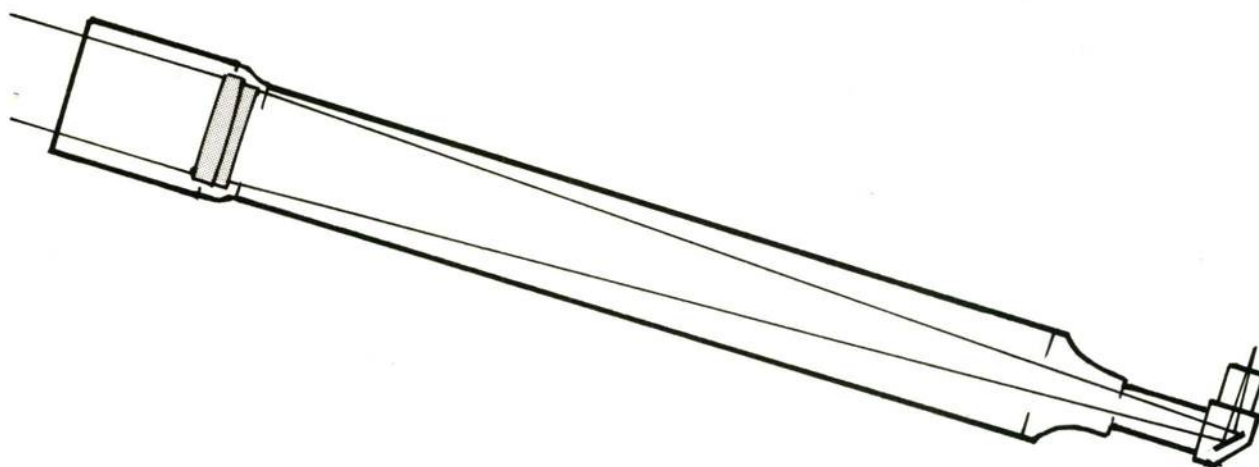
should serve to indicate how well the design works! Its simplicity makes the refractor a fine choice for you if you're just beginning.

Refractors have one main optical element — the *objective lens* — permanently mounted and aligned in one end of the telescope tube. With the eyepiece inserted at the opposite end, the tube is completely closed so it remains dust and moisture free. The only maintenance required in normal use is periodic cleaning of the objective's external surface; with a little care, it will last a lifetime.

Newspaper ads for small refractors often emphasize maximum power or magnification. You should ignore these claims for the most part. No telescope — whatever its design — can deliver good performance with more than 90 or 100 power per inch of aperture, and only then under superb seeing conditions. Normally, magnifications of 50 or 60 power per inch are the most acceptable. On nights of bad seeing, higher magnifications merely magnify the bad seeing! It's the telescope's *aperture* (diameter of the objective) that's really important. Telescopes with larger apertures can gather more light from celestial objects than those with smaller apertures, and deliver high resolution (that is, you can see more detail). All things being equal (instrument quality and seeing conditions), a larger aperture telescope will always outperform one of lesser aperture. Refractor apertures range in size from less than one inch to the 40 inch Yerkes Observatory lens (the largest in the world).

In comparison to other types of telescopes, however, refractors are relatively expensive per inch of aperture, as well as bulky. If you want a telescope with an aperture greater than four inches, your best bet would be a reflector or catadioptric instrument. Larger refractors are good values if you specifically need a refractor, but they are very expensive and require permanent housing.

A popular beginner's telescope is the widely available 2.4 inch (60mm) refractor. It is in this small aperture category that the refractor is the best value. Small refractors are readily available and often pro-



Refractor Telescope Suppliers & Dealers

Name	Available	Catalog	Delivery	60A	60E	3"E	3.1"E	4"E
Colonial Optical Co., Inc. (Mayflower) 8401 S. LaCienega Blvd. Dept. AM-77 Englewood, CA 90301	mail orders & local dealerships	free	shelf item	\$140 to \$225	\$355	\$515	\$575	
Consumer Service Jason/Empire, Inc. Box 12370 Dept. AM-77 Overland Park, KS 66212	mail orders	free	shelf item to 1 month	\$99 to \$209	\$318		\$670	
Edmund Scientific Co. 300 Edscorp Bldg. Dept. AM-77 101 E. Gloucester Pike Barrington, NJ 08007	mail orders	free	shelf item			\$235 to \$275*		\$395 to \$445*
Meade Instruments 721 W. 16th St. Dept. AM-77 Costa Mesa, CA 92627	mail orders	free bulletin on specific telescope requests	shelf item		\$195		\$325 to \$389	\$1,175
Swift Instrument Corp. P.O. Box 562 Dept. AM-77 San Jose, CA 95106	local dealer- ships, camera stores, opti- cal shops	free	2 months	\$260	\$398			
Tasco Sales Inc. P.O. Box 380878 Dept. AM-77 Miami, FL 33138	mail orders	free catalog reprint for specific inquiries	shelf item	\$100 to \$350	\$450			
Unitron Scientific, Inc. 101 Crossways Park West Dept. AM-77 Woodbury, NY 11797	mail orders	free	2 to 6 months	\$289	\$460 to \$572*	\$688 to \$795*		\$1,273 \$1,403* \$2,493*
Sears Roebuck & Co.	mail order catalog	fall/winter 1977 catalog	shelf item to 2 weeks depend- ing on demand	\$90 to \$120	\$179		\$350	
University Optics Co. 2122 E. Delhi Rd. Dept. AM-77 Ann Arbor, MI 48106	mail orders	free	shelf item, depending on demand				\$300	

A = Altazimuth Mount E = Equatorial Mount * = includes clock drive

Editors Note: The telescopes listed do not necessarily represent the entire line offered by the manufacturer. Prices are subject to change, so readers are advised to verify the price when ordering.

vide viewing satisfaction belying their modest prices. Standard sizes are the 2.4 inch (60mm), 3 inch (76.2mm), 3.1 inch (80mm) and 4 inch (102mm). You'll find that as aperture increases, price goes up — even disregarding for the moment the availability of additional accessories. A simple rule of thumb for telescopes of any particular design is: the larger the aperture, the more expensive the instrument. As with any major purchase, some "shopping around" is definitely in order before you buy. Identical telescopes may be sold under many different brand names — and often at vastly different prices.

Most major department stores and some camera shops sell refractors of 2.4 and three inch apertures. Refractors with four inch apertures are available (for the most part) only through mail order. While there are many American wholesaler/importers distributing telescopes to department store chains, there are relatively few Japanese manufacturers. (Interestingly, one major Japanese manufacturer distributes to the majority of American importers.) But even though only a few Japanese companies actually manufacture small refractors, they offer many different models with a wide range of optical quality.

Imported refractors are usually equipped with an assortment of accessory items — typically two or three eyepieces for low, medium and high magnifications; a Barlow lens which doubles or triples the magnification of each eyepiece; a star diagonal for ease in viewing objects directly overhead; an erecting prism (an astronomical telescope normally produces an inverted image) for terrestrial viewing; a sun screen for projecting and safely viewing the sun; a moon filter (a green colored glass that screws directly into the eyepiece to cut down the moon's glare), and often a dense filter for viewing the sun directly. *Discard the solar filter as soon as you purchase your telescope!* Sun filters which screw into the eyepiece are not safe; they can crack or melt, and the sudden flare of light can blind you almost instantly. Over-the-aperture sun filters are the only totally safe devices for direct solar viewing.

In general, spotting scopes and other 60mm refractors costing less than \$75 are intended exclusively for terrestrial viewing, and their optical quality is inferior to an astronomical telescope. Furthermore, they lack accessories such as a star diagonal and interchangeable eyepieces, making them less functional than a telescope specifically designed for astronomical viewing.

Another factor that influences price is the telescope mounting. The least expensive mounting is the *altazimuth* type — often a simple fork design that requires two separate motions in altitude and azimuth (vertically and horizontally) to follow an object across the sky. With such a simple mounting, some of your observing time will be spent recentering your subject (a bit frustrating!). In other, more expensive models, the altazimuth mount is equipped with slow motion controls that minimize centering problems.

Be prepared to spend between \$100 and \$200 for a

2.4 inch refractor of "adequate" quality for sky viewing, with an altazimuth mount and few accessories. The upper limit for a 2.4 inch refractor on an altazimuth mount is about \$350. Generally, as the price increases with various models, so does the overall mechanical quality improve. Tripods become more sturdy, and the accessory gadgets more elaborate.

More convenient is the *equatorial* mounting, which requires only a single motion (in right ascension) to keep the observed object centered. Here, you must weigh convenience against cost because an equatorial mounting may double the price of a refractor. For ultimate convenience, clock drive systems are available with equatorially mounted refractors. With an electric clock drive, you're free to concentrate on viewing while your object remains centered for hours at a time. But clock drives provide yet another additional expense. Costs for equatorially mounted 60mm refractors vary between about \$195 and \$450.

Whether your choice of mount is altazimuth or equatorial, mechanical rigidity will be important to your viewing pleasure. No matter how fine the telescope may be optically, it's useless if it trembles in a slight breeze. If you can inspect your instrument before purchase, rap the tube sharply while observing an object at high magnification. If the instrument requires more than five or six seconds to settle, it may prove more frustrating than rewarding.

While today's high quality 60mm refractors shed some doubt on the wisdom of investing in a three inch refractor, a three inch aperture provides better resolving power (ability to separate two points of light) and light grasp (ability to see dim stars) than a 2.4 inch. Prices range from about \$235 to \$795.

The next largest size telescope that will allow observation of more useful detail than could be viewed in a three inch is the four inch aperture refractor. From stripped down, bare bones equatorial minimum to pedestal mounted, gadget-fat maximum, four inch refractors cost between about \$395 and \$2,500. Priced beyond the realm of most pocketbooks, refractors larger than four inches require both permanent housing and confirmed enthusiasm for refractors.

A modest sum spent on a small refractor is good for many years of enjoyable viewing. Though many observers will eventually aspire to higher apertures, others will find the small instruments totally satisfactory. Many of the great observational astronomers of the past (such as Dawes, Webb and Olcott) did most of their work with three and four inch refractors.

Reflectors

If any telescope can be considered the "typical" observer's telescope, it must be the Newtonian reflector. This telescope has a concave primary objective mirror which focuses and reflects light to a smaller, flat secondary mirror called a *diagonal*. The diagonal, tilted at a 45 degree angle to the optical axis of the primary mirror, reflects the image produced by the primary to an eyepiece which magnifies it.

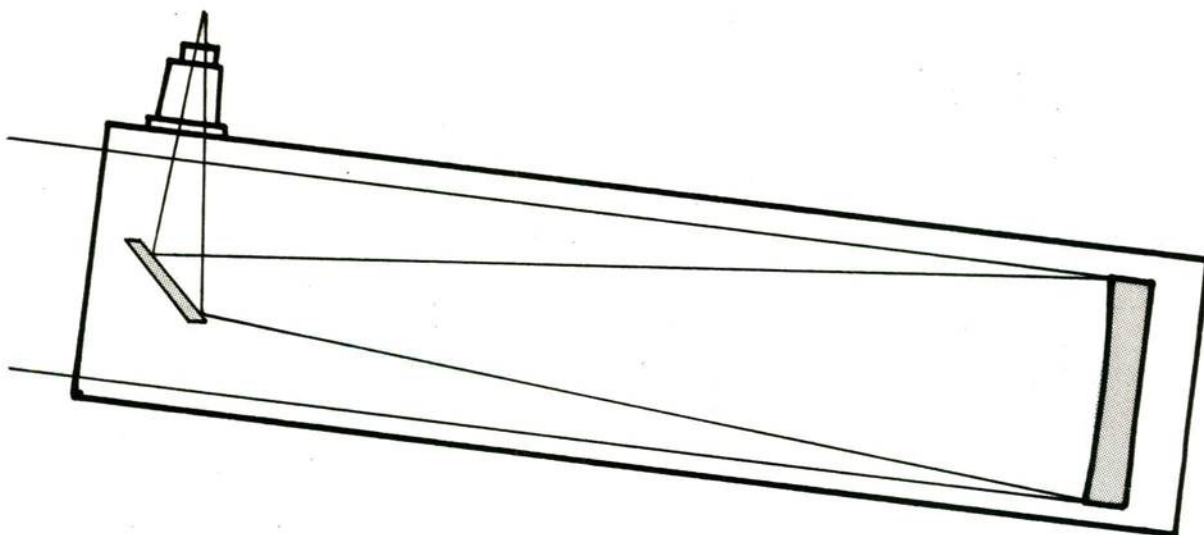
The biggest advantage of the Newtonian reflector is its low cost. The least expensive four inch equato-

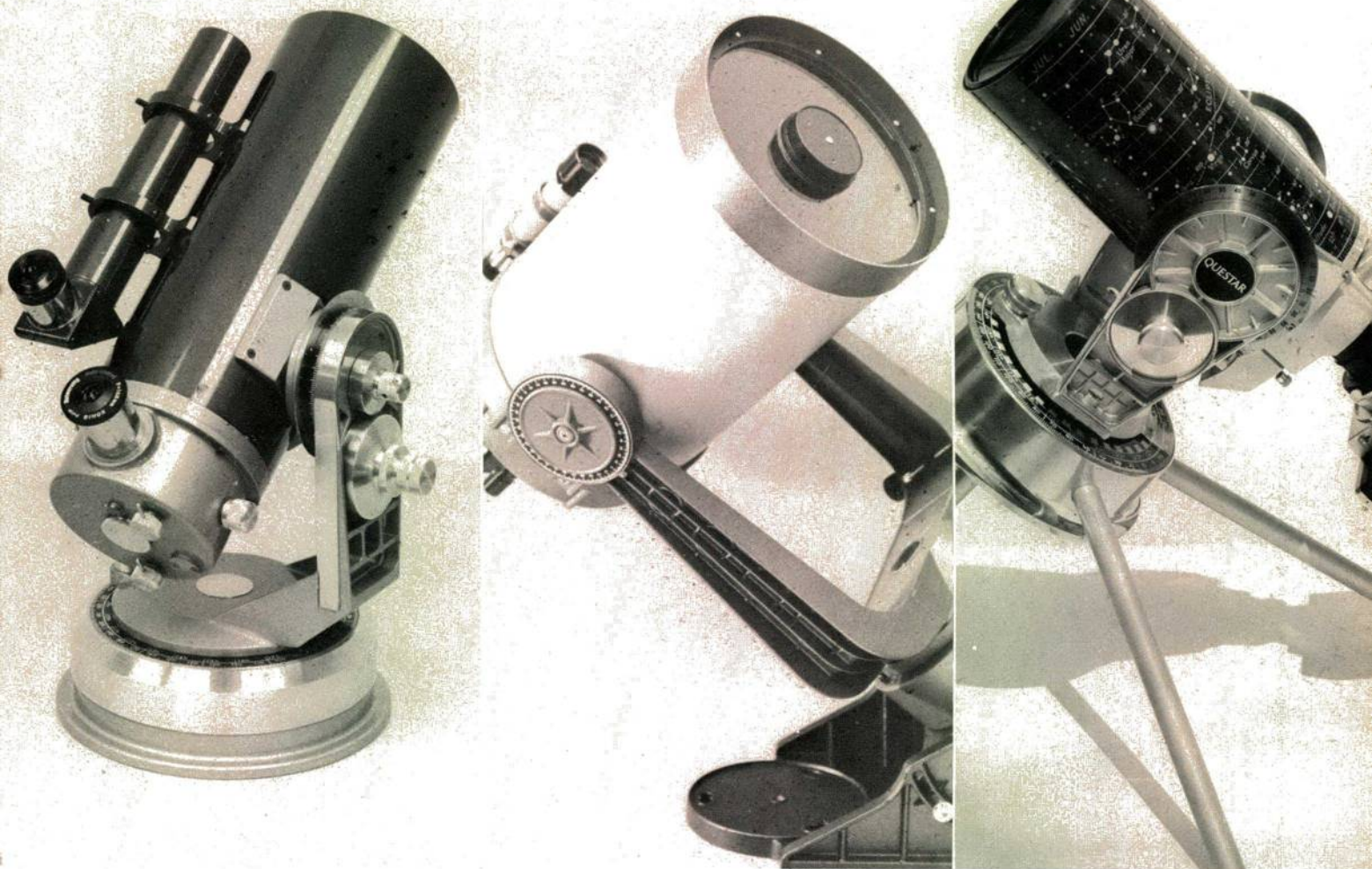
Newtonian Reflecting Telescope Manufacturers

Name	Catalog	Delivery	3"	4"	4-1/4"	4-1/2"	6"	8"
Cave Optical Co. 4137 E. Anaheim Dept. AM-77 Long Beach, CA 90804	\$1	9-16 weeks					\$295 to \$590*	\$425 to \$765
Criterion Manufacturing Co. 620 Oakwood Ave. Dept. AM-77 West Hartford, CT 06110	free	30-60 days (6") 4-5 months (8")					\$265*	\$400
Edmund Scientific Co. 300 Edscorp Bldg. Dept. AM-77 101 E. Gloucester Pike Barrington, NJ 08007	free	immediate — except 6" and 8", 30 days	\$60A to \$99A		\$179 to \$220*		\$399	\$699
A. Jaegers 691 Merrick Rd. Dept. AM-77 Lynbrook, NY 11563	free	immediate		\$48A		\$157		
Star-Liner Co. 1106 S. Columbus Blvd. Dept. AM-77 Tucson, AZ 85711	75¢	4-13 weeks					\$350 to \$1,045	\$450 to \$1,175
Consumer Service Jason/Empire Box 12370 Dept. AM-77 Overland Park, KS 66212	free	shelf item to one month	\$167A			\$334		
Meade Instruments 721 W. 16th St. Dept. AM-77 Costa Mesa, CA 92627	free infor- mation sheet	10 days					\$300*	\$430*
Star Instruments P.O. Box 1606 Dept. AM-77 Costa Mesa, CA 92626	\$1	immediate					\$375 to \$670*	\$470 to \$800* \$865 to \$970*
Tasco Sales P.O. Box 380878 Dept. AM-77 Miami, FL 33138	free	immediate	\$300A			\$400		

* = includes clock Drive A = altazimuth (all others equatorial)

Editor's Note: the telescopes listed do not necessarily represent the entire line offered by the manufacturer. Prices are subject to change, so readers are advised to verify the price when ordering.





The three photographs above illustrate the catadioptric type of telescope — a combination of lenses and mirrors. Left: Optical Techniques offers a single arm mount on this four inch Maksutov telescope. Center: This five inch Schmidt Cassegrain on a fork mounting is manufactured by Celestron International. Right: Questar Corp. makes this 3-1/2 inch Maksutov on a fork equatorial mount.

rial refractor without clock drive costs about the same as the most expensive 4-1/2 inch equatorial Newtonian reflector.

Newtonian reflectors have other advantages besides cost, however. In some ways, they outperform refractors. For example, light passing through a lens always creates color distortion called *chromatic aberration*. In the refractors discussed in this article, this distortion is minimized by specially designed two-element objective lenses (*achromatic lenses*) which correct most of the visible color distortion. Since light does not pass through *any* lenses in the Newtonian reflector, chromatic aberration is eliminated. On the other hand, a refractor generally has a slight advantage in performance over a Newtonian reflector of the same aperture. Secondary mirror obstruction in Newtonians results in marginal loss of contrast, brightness and image definition.

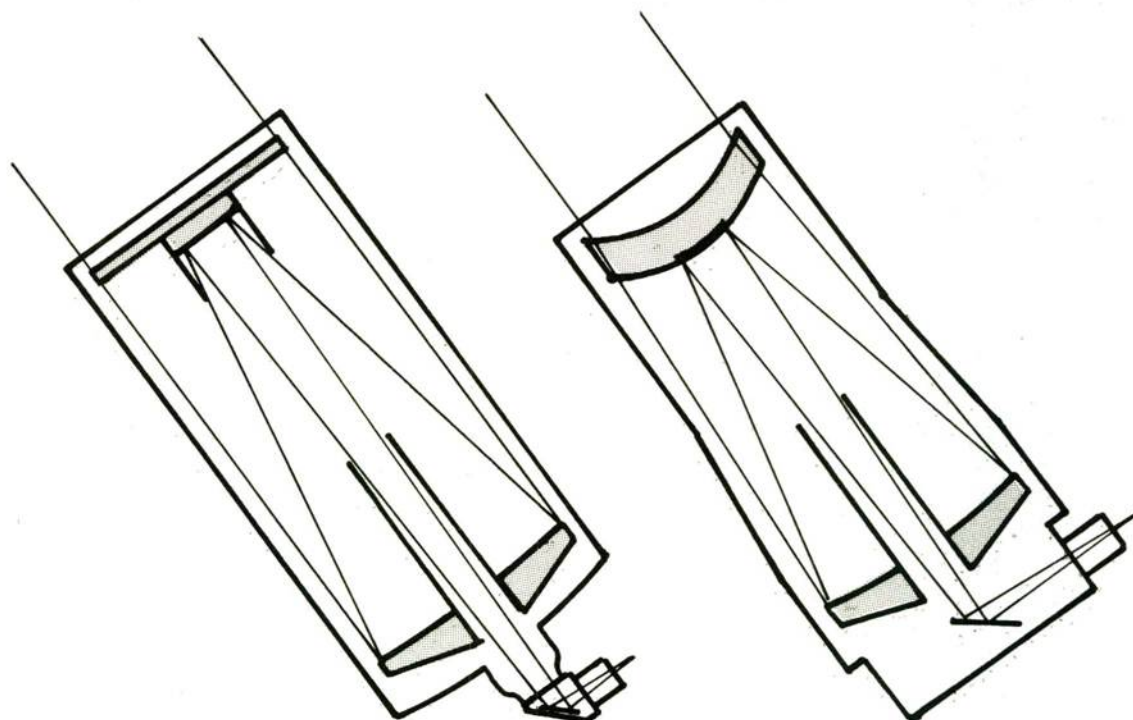
The Newtonian's open tube allows dust and film to accumulate on optical surfaces, so you'll have to dismantle it occasionally for cleaning. The aluminum coating of the exposed mirror surfaces can deteriorate

over the years — especially in areas of severe air pollution — so you may need to have them recoated periodically. Furthermore, because the reflector uses two reflective optical elements to bring light rays to a focus in front of the eyepiece, it is essential that they both be centered, or *collimated* — a frequent and unavoidable operation if the telescope is transported or bounced around. These operations are not difficult, however, and the reward — for a given instrument — is the greater performance only large apertures will yield.

Quality reflectors are not available as shelf items in department stores and must be ordered by mail. Unlike refractors, Newtonian reflectors are manufactured by American companies. Since there are very few such companies in the United States, competition is very keen. As a result, you, the buyer, benefit by receiving the highest optical quality each manufacturer can provide.

An important point to remember is that reflectors are generally made as orders come in, and you should be prepared to wait from one to eight months for delivery of your telescope. If you become impatient, feel free to drop the company a line inquiring about the progress on your instrument.

Price variations within a Newtonian reflector size are due less to variations in optical quality and more to differences in accessory equipment and mechanical engineering. For example, almost without excep-



Catadioptric Telescope Manufacturers

Name	Where Available	3"	3.5"	4"	5"	6"	7"	8"
Celestron Pacific 2835 Columbia St. Box 3578-AM Torrance, CA 90503	mail order and selected dealers				\$795			\$995
Criterion Mfg. Co. 620 Oakwood Ave. Dept. AM-77 West Hartford, CT 06110	mail order only					\$610		\$875
A. Jaegers 691 Merrick Rd. Dept. AM-77 Lynbrook, NY 11563	mail order only	\$200						
Questar Corp. Route 1 Dept. AM-77 New Hope, PA 18938	mail order only		\$925 - \$1,870				\$2,950 - \$5,970	
Starliner Co. 1106 S. Columbus Blvd. Dept. AM-77 Tucson, AZ 85711	mail order only					\$725		\$895 - \$1,448
Tasco Sales Inc. P.O. Box 380878 Dept. AM-77 Miami, FL 33138	mail order only					\$1,995*		
Optical Techniques Inc. P.O. Box 275 Dept. AM-77 Newtown, PA 18940	mail order only			\$750		\$1,250		

*Equatorial

Editors Note: The telescopes listed do not necessarily represent the entire line offered by the manufacturer. Prices are subject to change, so readers are advised to verify the price when ordering.

Rich Field Telescope Manufacturers

Name	Catalog	Delivery	Item	Price
Edmund Scientific Co. 300 Edscorp Bldg. Dept. AM-77 101 E. Gloucester Pike Barrington, NJ 08007	free	stock	4-1/4"	\$150
A. Jaegers 691 Merrick Road Dept. AM-77 Lynbrook, NY 11563	free	stock	5" equatorial	\$307
Cave Optical Co. 4137 E. Anaheim Dept. AM-77 Long Beach, CA 90804	\$1	9-16 weeks	6" 8"	\$354 \$405
Starliner Co. 1106 S. Columbus Blvd. Dept. AM-77 Tucson, AZ 85711	75¢	45-70 days	6" 8"	\$425 to \$750 \$505 to \$940
Star Instruments P.O. Box 1606 Dept. AM-77 Costa Mesa, CA 92627	\$1	immediate	6"	\$280 to \$360
Editors Note: The telescopes listed do not necessarily represent the entire line offered by the manufacturer. Prices are subject to change, so readers are advised to verify the price when ordering.				

tion, Newtonian reflectors in all sizes are mounted equatorially (the sturdier the mount, the higher the cost, and the happier you'll be with your telescope's performance!).

Mirror specifications in manufacturer's catalogs and literature provide clues to optical quality. The following are three guidelines to watch for:

1) Both the primary and secondary mirrors should be figured to at least 1/4 wave. You will pay increasingly more for mirrors figured to 1/8 or better. Mirrors of less than 1/4 wave will not produce adequately sharp images for celestial viewing. Both mirrors should match in terms of wave, for best performance.

2) The primary or objective mirror often has a focal ratio of f/6 to f/8 — optimum for all-around backyard viewing. Newtonians with focal ratios of f/4 or f/5 are considered *rich field telescopes* and are ideal for viewing faint objects (like galaxies and nebulae). The short focus telescopes are far more portable — and ultimately can do everything the longer focus instruments can.

3) If the primary mirror is not parabolized, it should have a focal ratio no lower than f/10. These are usually the least expensive Newtonians available.

Refer to the Newtonian reflector telescope manufacturers table accompanying this article for the price ranges you can expect.

The long-time popularity of the Newtonian reflector speaks highly of its economy and usefulness. You'll have to weigh for yourself the advantages and disadvantages of reflectors and refractors before choosing the design that best suits your specific needs.

Catadioptrics

A modern blend of refractor and reflector, the

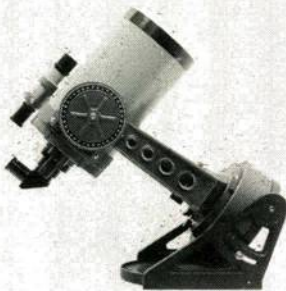
catadioptric or compound telescope system comes in two basic designs for visual observing — the Maksutov and the Schmidt-Cassegrain. Light rays entering the telescope are "folded" and amplified by a lens/mirror partnership, resulting in a very compact instrument. A typical eight inch model weighs less than 24 pounds with a tube only 1-1/2 feet long. The catadioptric telescope has a completely closed tube, protecting mirror coatings from the elements and eliminating thermal currents — so it shares certain advantages with both refractors and reflectors.

There is, however, one decided disadvantage to a catadioptric system. Most models are priced very high — near the upper limit that separates the "amateur" from the "professional" market. Catadioptric telescopes are currently quite popular and heavily advertised, but you should be aware of the large difference in cost between this system and the others discussed here. Above all, keep your own resources in mind before buying — and remember to buy what you need!

Each telescope type offers its own special appeal and features for consideration. Refractors are noted generally for sharp planetary images; reflectors supply the best views in color contrast (double stars and nebulae, for instance), and catadioptrics are portable and produce the sharpest images over the widest field.

Remember to avoid any scope that is too large for your familiarity with the equipment. And above all, especially with a small refractor that comes in a "nice" wooden storage box, don't disassemble your telescope. Keep it out and ready to use! It's only actual use of the telescope that eventually produces a good observer and a happy and satisfied astronomer. 

Celestron Telescopes—Professional Quality Parts and Accessories



Get our special package deal and price on a new Celestron. Call us toll FREE!

As one of the nation's leading Celestron dealers, we want to put you behind the controls of one of these fine instruments. Get our free offer of a new 8 x 50 wide angle finder when you purchase a new Celestron-8. In any case, it will pay you to call us if you are thinking of purchasing any of the new Celestrons including the exciting new 3.5" model!

Remember, it doesn't cost you a cent to call for a price quotation on our new toll free telephone line. Call us today and join the long list of our friends and fellow Celestron owners.

New for Celestron! An 8 x 50 wide angle finder with a built-in True Polaris North indicator.

Our exciting new wide angle 8 x 50 finder lets you get perfect celestial pole alignment without bolt-on gadgets. A unique 0.9 degree dual function reticle makes it all possible. This giant right angle finder features a special cast aluminum bracket that replaces your present finder without modification. The orange color matches the main tube. Coated optics. Six adjusting screws. Fits in the case. Instructions included. A unique and useful addition to your Celestron.

Model A (T.P.N. reticle).....\$49.95 ppd.
Model B (standard cross hair).....42.95 ppd.



NEW CELESTRON ACCESSORIES

You've seen the rest, now buy the best. Each of our fine custom accessories is designed to look like an integral part of your telescope.

Celestron Dew Cap. Orange color. On and off in seconds.....\$34.95 ppd.
Heated Dew Cap. The Safe one! 12 volt D.C. with on-off switch and indicator light. Orange color. \$59.95 ppd.

MIR-O-TESTER



Get a better mirror! Parabolize it with one of our fine instruments. Order your Mir-O-Tester today!

When your mirror has reached the polishing stage, give it the Foucault test with this fine tester. Our improved Mir-O-Tester offers .001" accuracy with a micrometer-type dial. Kit model is easily assembled from precision parts. Assembly instructions and zonal masks included.

Assembled.....\$34.95 ppd. Kit.....\$18.95 ppd.



DEEP-SKY EYEPIECES

Extra-wide field Kellners for breath taking views of space!

Model A With its special enlarged field lens, it yields the widest field possible. Threaded barrel.

40mm. KMA.....\$16.95 ppd.
Model B Same wide field as above, only precisely parfocal. We recommend this model for eyeglass wearers.
40mm. KMP.....\$19.95 ppd.



NEW 2" ADAPTER for CELESTRONS and DYNAMAX-8

Open up a whole new world of deep-sky viewing!

A very economical way to put the new 2" eyepieces on your Schmidt-Cassegrain. Slip our 60mm. Kellner in your scope and get 33X. Perfect for those elusive nebulae. Thumbscrew holds your eyepiece.

\$25.50 ppd.

2" right angle diagonal. Uses first surface mirror. For use with the above adapter.....\$119.95 ppd.

CELESTRON PRICE QUOTATIONS CHARGE CARD ORDERS, C.O.D.s

Call Toll Free (800)-521-2828

all states except Alaska, Hawaii, and Michigan

(9:30 a.m. - 4:30 p.m. Mon. - Sat.)

Second Line (313) 761-0430

A NEW REFRACTOR!

Introducing the compact new 3.1" model by University Optics.

A new, compact, easy to use f/11 refractor with big telescope performance. High quality air-spaced objective. Adjustable equatorial mount lets you follow celestial objects with ease. Coated optics. Includes eyepieces, Barlow, star

diagonal, erecting prism, and more. We feel this is the ideal telescope for those of you seeking an easily transportable refractor at a reasonable price. Don't delay, place your order today.

3.1" Refractor.....\$299.50 ppd.

NEW DUAL FUNCTION RETICLE



The first illuminated reticle designed to meet all of your most critical guiding needs.

This amazing new dual-light reticle lets you select the correct color depending on sky conditions. Flip a switch for amber or special night vision green. 12.5mm. orthoscopic design. Adjustable brightness control. Focusable cross-hairs. 4 feet of power cord. Batteries included. Eyepiece weighs only 4 oz. 1 1/4" O.D. This fine illuminated orthoscopic will prove to be one of your most valued photographic aids.....\$39.50 ppd.

thoscopic design. Adjustable brightness control. Focusable cross-hairs. 4 feet of power cord. Batteries included. Eyepiece weighs only 4 oz. 1 1/4" O.D. This fine illuminated orthoscopic will prove to be one of your most valued photographic aids.....\$39.50 ppd.

ZOOM MONOCULAR

One of the most unusual and high quality items we have ever offered.

This excellent 8-20 power zoom monocular also serves as a fine telephoto lens for your 35mm. camera. Use it visually for astronomy or nature study. Attach it to your camera to capture your view on film. It features a big 45mm. objective with a 7 lens optical system. Wide angle design. Quality carrying case.

8-20X ZOOM.....\$79.95 ppd.
Camera adapter.....5.95 ppd.
(please give lens filter size)



ACCUSTAR

Enjoy your telescope more. Get sidereal time any place, any time, instantly!

Learn how to use your telescope's setting circles, how to point your scope, and the importance of sidereal time in astronomy. We feel that no telescope owner should ever be without Accustar. You get the Accustar instrument, Sky Finder overlay, and 90 page textbook.

\$11.95 ppd.

11 x 80mm. CFZ.....\$129.00 ppd.
20 x 80mm. CFZ.....\$129.00 ppd.

FREE OFFER! When you order either of the above binoculars, we will give you a free pair of soft rubber eyecups and a camera tripod adapter.

WE ALSO CARRY 80mm. and 120mm. MILITARY SPECIFICATION BINOCULARS. PRICES RANGE FROM \$800 to \$3000.



DEEP-SKY BINOCULARS

Our new 11 x 80 and 20 x 80 CFZ giant binoculars will meet your most critical deep space viewing requirements.

We improved the quality on these popular 80mm. binoculars even more! They now feature U.V. coated objectives in addition to fully coated eyepieces. Perfect for astronomy or nature study. Center focus design. We suggest the 11 power model for rich-field observation of the stars.

11 x 80mm. CFZ.....\$129.00 ppd.
20 x 80mm. CFZ.....\$129.00 ppd.

FREE OFFER! When you order either of the above binoculars, we will give you a free pair of soft rubber eyecups and a camera tripod adapter.

WE ALSO CARRY 80mm. and 120mm. MILITARY SPECIFICATION BINOCULARS. PRICES RANGE FROM \$800 to \$3000.

ZOOM FROM 8.4 to 21 mm.



This is the same fine quality zoom eyepiece we have sold through the years and we have refined it even more! Built-in astro filter adapter at no additional cost. Coated lenses with precision construction throughout. 1 1/4" O.D. Smooth zoom action for those close-up views. Truly an excellent value.....\$29.95 ppd.

PARFOCAL EYEPIECES

Look! We rolled back the prices to 1970 levels on these fine orthoscopes.



These precisely parafocal 4-element orthoscopes are unexcelled in color correction and resolution. Fully coated optics with a nice 45° field. Standard 1 1/4" O.D. barrel with built-in filter adapter. Whether for use in the research laboratory or in the home observatory, these are the eyepieces you can count on.

Focal lengths: 4, 6, 9, 12.5, 18, and 25mm.
each \$14.95 ppd.

AN EXCITING NEW 4-1/4" R.F.T.

This is one of the finest wide field telescopes we have ever used. Perfect for wide angle views of the moon, stars, and comets! Ultra portable. Take it anywhere. Sealed optical system. Standard 15X eyepiece included.

Quality engineered by Edmund Scientific to give years of flawless performance.

4 1/4" R.F.T.....\$149.95 ppd.



PROFESSIONAL FOCUSING MOUNTS



UNIVERSAL. Our most popular mount. We have sold this helical rack and pinion for years with excellent results. Cheap copies have appeared, but they have never duplicated its superior design. Fits all tube sizes. 1 1/4" I.D.\$15.95 ppd.

VEGA 1. A very unique mount. Mount rotates 360° on base. By removing one screw, top portion of mount can be removed for first focus photography. Helical rack and pinion has over 3" travel. Base to fit your tube or available flat. 1 1/4" I.D. Thumbscrew holds ocular.....\$29.95 ppd.

VEGA 2. When professional telescope makers choose a big mount for 8" or larger scopes, this unit fills the bill. Takes the giant 2" O.D. eyepieces as well as 1 1/4" O.D. units. Cast aluminum construction with helical cut rack and pinion. Thumbscrew holds ocular. The large focusing knobs make using it a pleasure.....\$28.95 ppd.

PROFESSIONAL EYEPIECES



Through the years, the ones they have all tried unsuccessfully to duplicate.

The high quality of our Professional Series eyepieces has been well established over the years in every part of the world. Camera quality orthoscopic optics with multi-coating for maximum light transmission. Warranted to equal or exceed the performance of any eyepiece sold today or your money refunded. Each comes with fitted carrying case.

4mm., 6.8mm., 10.2mm., 16mm., and 28mm. each \$33.50 ppd.

NEW FREE CATALOGUE GIFT WITH EVERY ORDER

UNIVERSITY OPTICS INC. 2122 E. Delhi Rd. Ann Arbor, Mich. 48106

WEST COAST OUTLET UNIVERSITY OPTICS WEST
P.O. Box 6038, Phone (213) 541-4331
Rolling Hill Estates, CA. 90274

The New Edmund "SUPERSTARS" — latest developments in our 35-year commitment to astronomy. **Precision Newtonian Instruments Designed With Features Demanded By Professional And Serious Amateur Astronomers.**

\$699⁰⁰

Orion Nebulae
Through 8"



SPECIFICATIONS — 8"

- Quality $\frac{1}{8}$ -wave optics**
- Fully adjustable
- $1\frac{7}{8}$ " secondary minor axis
- 7" O.D. phenolic tube**
- Rugged aluminum end rings
- Quick-release tube rotation
- Foldable equatorial mounting**
- All aluminum alloy castings
- Smooth R.A. and Dec. motion**
- Adjustable friction clutches
- Synchronous clock drive
- Fine-adjust declination
- 33X RKE eyepiece**
- Engraved drum setting circles
- $1\frac{1}{4}$ " standard rack and pinion focusing mount
- 7X Finder, 5° field**

Lightweight 6-Inch f/6

Superb performance fulfilling demands placed on a telescope by schools and amateur astronomers. Compared to conventional f/8 systems this new telescope is more compact, easier to use and gives a wider field of view while maintaining the light-gathering capability and resolution of any 6" optical system.

The Unique 8-Inch f/5

Designed With The Astrophotographer In Mind

After extensive research and lengthy discussions with prominent professional and amateur astronomers, our expert engineering staff designed this exceptional all-purpose telescope. The precision, semi-fast f/5 Newtonian optical system is ideally suited for first-focus astrophotography, greatly reducing exposure times for extended objects compared to typical 8" f/10 systems. This lightweight, foldable telescope offers superior performance, versatility and a large selection of optional accessories. Weighing just 70 lbs., the unit breaks down into 3 major subassemblies for ease of use.



SPECIFICATIONS — 8"

- Dynamically rigid optical system**
- Quality $\frac{1}{8}$ -wave primary and secondary mirrors
- Housed in sturdy phenolic impregnated tube $9\frac{1}{2}$ " O.D.
- Fully adjustable mirror mounts are integral to the tube's cast aluminum end rings
- Secondary minor axis — $2\frac{5}{8}$ "
- Foldable equatorial mounting on tension tripod base**
- All aluminum alloy castings
- Smooth R.A. and Dec. motion, self-lubricating**
- Adjustable friction clutches
- Synchronous clock drive
- Fine-adjust declination control
- Quick-release tube rotation
- 2" I.D. rack and pinion focusing mount**
- $1\frac{1}{4}$ " adapter for standard eyepieces
- 2" O.D. to "T" mount adapter
- 36X RKE eyepiece**
- New Edmund design — ray-traced
- Engraved drum setting circles**
- 9X Finder, 6° field**
- Interchangeable $1\frac{1}{4}$ " standard reticle eyepiece

\$399⁰⁰



Crescent Moon
Through 6"

EDMUND SCIENTIFIC CO., Dept. Y-17, Edscorp Building, Barrington, N.J. 08007

☐ Please send me _____ 8" Telescope(s) @ \$699 plus collect freight charges.

☐ Please send me _____ 6" Telescope(s) @ \$399 plus collect freight charges.

Enclosed is my ☐ Check ☐ M.O. for total of \$ _____

Please charge my ☐ Am. Exp. ☐ VISA ☐ MC

Exp. date _____ Card # _____

Interbank # _____ Sig. _____

☐ Please send me the detailed Telescope Brochure (No. 7790) and the latest Edmund catalog (Y-18).

FREE!

Name _____

Address _____

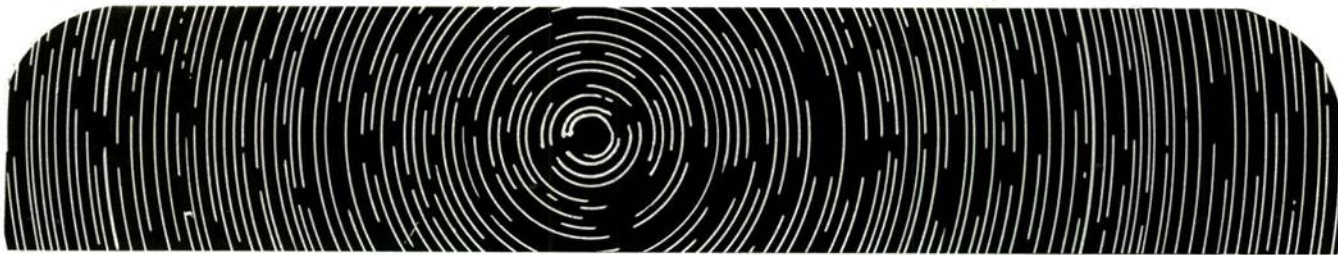
City _____

State _____

Zip _____

30-Day Money-Back GUARANTEE. You must be completely satisfied or return your telescope within 30 days for a full refund.

For more information and detailed specifications see the newest Edmund catalog and our Telescope Brochure No. 7790



GAZER'S GAZETTE

“Stoplight” Stars: The Red Variables

by

Thomas C. Bretl

The night sky is so rich in double stars, clusters and nebulae, that what begins as a mere “sightseeing tour” of the heavens can easily become a lifelong hobby. Many stargazers, however, soon tire of just sitting back, observing, and admiring the universe around them. They feel the urge to keep records of the sights they see and, if possible, make some contribution to the knowledge that has been accumulated over the centuries about the subject which fascinates them so.

Variable star observing is one area of astronomy in which careful record keeping is a “must”, and in which the average observer can still provide useful data without needing access to fancy or expensive equipment. Unlike eclipsing variables (see “Watch A Stellar Eclipse”, *ASTRONOMY*, June 1977), which vary in brightness over a period of hours, many variable stars go through their paces in periods measured in weeks or months, and behave quite unpredictably from one rise in magnitude to the next. In order to better understand the nature of these stars, and to develop models explaining their sometimes regular and sometimes erratic behavior, we need numerous observations — too time consuming for the professional, but easily accomplished by a large dedicated group of astronomy enthusiasts working together. Any size telescope can be put to good use for this work, and in many cases binoculars (or no optical aid at all!) will do the job. A few good star charts, and a considerable amount of care and patience, are all that is really required.

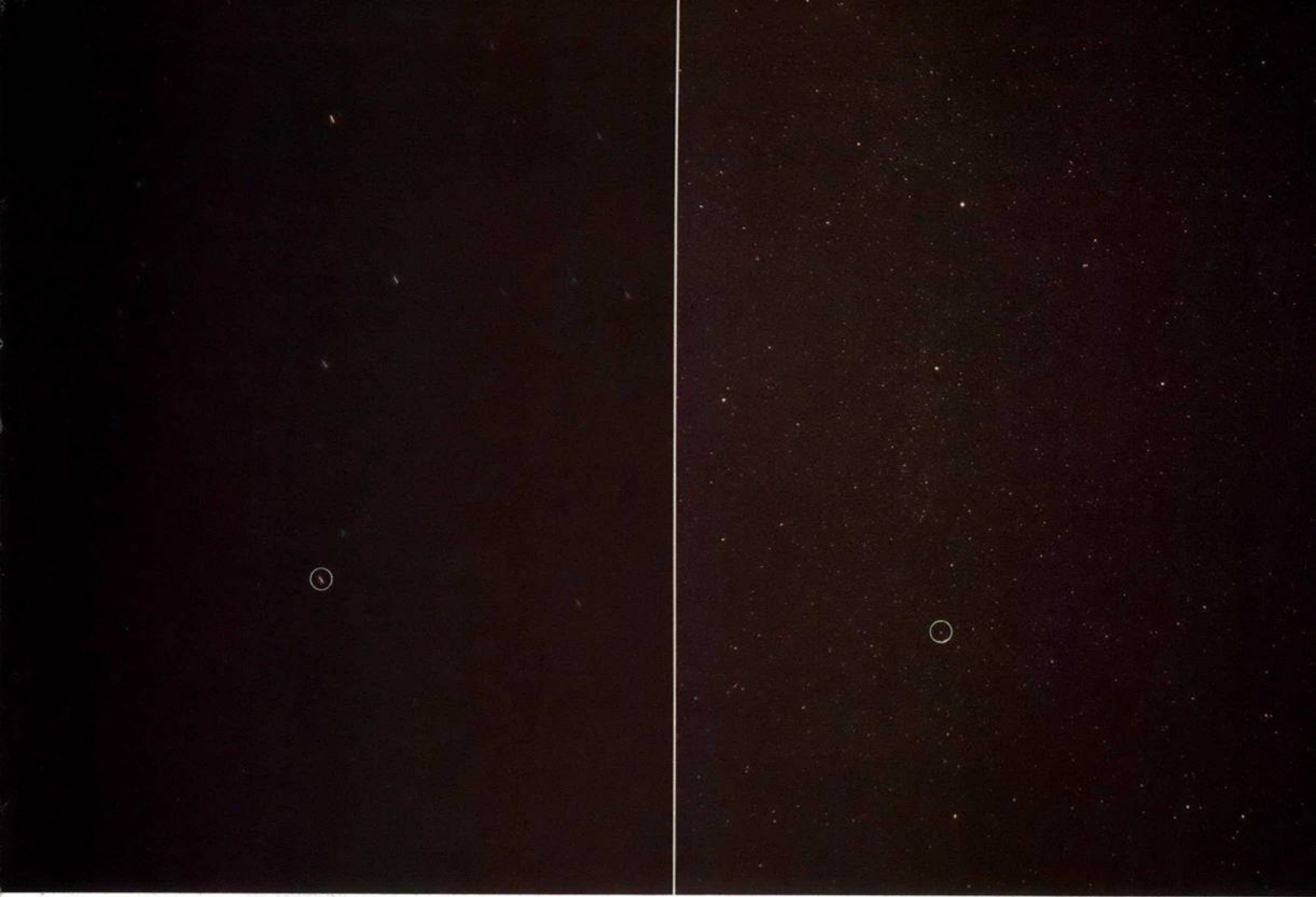
Among the less dependable variable stars are

long-period variables (sometimes called red variables). These stars are red giants with a number of special characteristics in their spectra. Their brightness generally oscillates over a period of 200 to 400 days, with a total change from minimum to maximum of somewhere between three to eight magnitudes. These variations usually occur with fairly reliable regularity, but small changes from the norm are common, and individual maxima and minima may be much more extreme than what we might expect on the basis of previous observations. In the telescope, long-period variables often have a very striking, unmistakable red color, and they stand out well even in a crowd of other equally bright stars.

Observing long-period variables basically involves three different tasks: finding and positively identifying them, estimating their brightness, and keeping a careful record of your results.

Despite the fact that you may be hunting for a star which at times is extremely faint, finding a particular variable is not as difficult as it might seem. A reliable star atlas and sufficiently detailed charts of the region immediately surrounding the variable in question are all you’ll need. Some of these detailed charts accompany this article; others can be obtained from organizations such as the American Association of Variable Star Observers (AAVSO), which welcome the membership of serious observers.

To find a particular variable, start by carefully plotting its position in the star atlas, and then look for a relatively conspicuous star which lies in the same general area of the sky. After locating this brighter



Long-period variable stars are red giants, and they can be easily recognized by their markedly red color. Top left: This 30 second exposure on High Speed Ektachrome, taken in January 1977, shows Mira in the constellation Cetus — the most famous of all long-period variables. Top right: Chi Cygni lies in one of the richest regions of the Milky Way. This photograph, obtained in the summer of 1976, is a nine minute exposure on GAF 500, obtained with a 50mm lens at f/3.5. Note the bright reddish color of both these stars. Photograph by Robert Ficara.

star (often called the "key star") in your telescope, "star hop" toward the position of the variable. As the area immediately surrounding the variable comes into view, you should be able to pick out some of the patterns of stars that are plotted on the more detailed chart. If you have trouble, it may help to draw a circle on the detailed chart that covers the same field of view as your telescope (at the magnification you are using), so that you have some idea of just how much you should be able to see at one time. (Leslie Peltier, a renowned observer of variables, recounted this little "trick" in his autobiography *Starlight Nights*. This idea — like most of his others — is excellent!) In many cases, you may also recognize the variable by its prominent reddish hue.

After positively identifying a variable star, the next step is to try to estimate its brightness. This is done by comparing it to other stars, called *comparison stars*, which are plotted on the chart with predetermined magnitudes printed next to them. (Note that these magnitudes are almost always written

without a decimal point. For example, the number 97 next to a star means it has a magnitude of 9.7.) You may find, for example, that the variable is definitely brighter than a comparison star of magnitude 10.2, but not as bright as another of magnitude 9.6. Does it seem to be about halfway between them in brilliance? Then your estimate should probably be 9.9. Is it much more similar to the 9.6 magnitude star than it is to the 10.2 star? Then perhaps 9.7 would be the most accurate estimate. You'll probably find that only one or two-tenths of a magnitude seems extremely slight at first — but with practice, you'll almost always be able to detect such small differences.

Since long-period variables do not change in magnitude quickly, you'll need to keep careful records of your observations — especially if you plan to contribute your efforts to a larger organization such as the AAVSO. Include in your records the name of the variable, together with the date, time, diameter and magnification of telescope used, seeing conditions, the magnitudes of the comparison stars you used to make your estimate, and any doubts you may have about the accuracy of your estimate. Observe your variables every two weeks or so, and you'll soon have enough data to see patterns of change and to construct, if you wish, your own "light curves" for these stars.

Of course, things are usually not quite as simple as they sound, and variable star observing is no excep-



Some Long-Period Variables

Variable	R.A. (1950)	Dec.	Average Magnitude Range	Period (days)	Comments
S Ceti	0 ^h 22 ^m	-09°36'	8.2 - 13.9	320	Easy to find near ϵ Ceti
X Cassiopeiae	1 ^h 53 ^m	+59°01'	9.8 - 12.1	428	Very colorful, beautiful field
α Ceti (Mira)	2 ^h 17 ^m	-03°12'	3.7 - 9.2	332	First variable positively identified
S Orionis	5 ^h 27 ^m	-04°44'	7.9 - 13.2	413	Near M-42
S Geminorum	7 ^h 40 ^m	+23°34'	8.8 - 14.0	293	Easy to find near κ Geminorum Same periods, different light curves
T Geminorum	7 ^h 46 ^m	+23°52'	8.7 - 13.7	287	
R Leonis	9 ^h 44 ^m	+11°39'	5.8 - 10.0	313	One of first discovered
T Canum Venaticorum	12 ^h 29 ^m	+31°47'	9.3 - 12.3	290	In region of galaxies
R Hydrae	13 ^h 26 ^m	-23°01'	3.0 - 11.0	388	Very wide range
Z Scorpii	16 ^h 03 ^m	-21°36'	9.1 - 13.2	353	Easy to find near ω^1 and ω^2 Scorpii
X Scorpii	16 ^h 06 ^m	-21°24'	10.9 - 14.2	199	
T Draconis	17 ^h 56 ^m	+58°14'	9.5 - 12.1	421	Very red!
X Cygni	19 ^h 49 ^m	+32°47'	5.1 - 13.3	407	One of first discovered; in Milky Way
Z Pegasi	23 ^h 58 ^m	+25°36'	8.4 - 12.9	321	Easy to find in Great Square

tion. You'll certainly encounter a number of problems on your own, and there are several sources of error and frustration in estimating the magnitudes of stars that you should be aware of before you get started.

If the variable and the star you are comparing it to are not in the same field of view, you'll have to shift your telescope from one to the other rather quickly in order to make your estimate. If, on the other hand, both the variable and the comparison star fit within the same field, it's important that you keep them an equal distance from the edge of the field to prevent any possible distortion. Also, you should try to observe the two stars in a way such that a line through them is parallel to a line between your eyes! In other words, when you look in your eyepiece, position yourself so that the stars are to the left and right of each other — not one above the other. This may be difficult to do without having to stand on your head on the top of a ladder (especially if you are using a reflector), but it *is* important, because if one of the stars is at the bottom of your field of view, it will almost always appear brighter than it really is! Sound ridiculous? Try this optical illusion sometime with two stars that seem of equal magnitude when observed "side by side".

Another problem in estimating stellar magnitudes is color. Long-period variables are often red, and red stars tend to become brighter and brighter the longer you stare at them. Since this is a property of your eyes and not of the star, you should try to estimate the magnitude of a very red star by taking rather quick glances at it, instead of one long hard look. You'll probably still find it difficult to make an accurate estimate of a really red star compared to others having less color contrast with their comparison stars,

When long-period variable stars are at or near their minimum brightness, it helps to have a bright, easily recognized object nearby to aid location and identification. Circled in this photo is S Orionis, situated not far from the Orion nebula (M-42). This is a 15 minute exposure on 103aF film, obtained with a 200mm lens at f/4.5. Photograph by Jack Newton.

but at least the "quick glance" method helps avoid needlessly large errors in judgment.

Finally, there is a psychological source of error in estimating the magnitudes of variables. If you know from your last several estimates of a particular star that it has been slowly rising in brightness, or if you know that it is predicted to be getting brighter, that knowledge may very well influence your decision in making a new estimate. It's best to try to forget all about a particular variable (except its location!) between observations, and to *not* consult your past records or published predictions before going out to observe. Make your estimate as bias-free as possible, and do not check to see what changes have occurred until *after* you are done. Then, if your data seems totally inconsistent, you might go back and make sure you were looking at the right star — but otherwise, don't change your mind! Remember, if long-period variables were totally and accurately predictable, there would be little reason to observe them at all!

The table on this page lists variables from different parts of the sky. Included are stars that are relatively easy to find, stars with a wide variety of magnitude ranges, and some of the most famous examples of long-period variables. When choosing a particular star to observe, remember the limiting magnitude of your telescope under usual observing conditions. It is easiest to make an estimate when the variable is within two to four magnitudes of that limit. In some cases, therefore, it is best to use only binoculars, or no optical aid at all.

When you go out to observe, try to be comfortable and relaxed. A very hasty observation made from an awkward and uncomfortable position at the eyepiece will invariably be a poor one. Most of all, have fun, and take time out to take a look at a nearby cluster or nebula. Variable star observing can be a useful and rewarding activity, but it should enhance — not diminish — the enjoyment of spending a night under the stars. 

"I would have figured it out a lot sooner," Copernicus told us, "if I had known about Unitron astrophotography."

The idea of seeing the stars and the planets better through a telescope did not startle Nicolaus as he looked at all the Unitron equipment in our showroom. What really got him were the photographic accessories.

"Imagine," he said, "making the stars and the planets stand still." The old astronomer was referring to the crystal-clear, uniformly sharp astrophotographs you can get with the superb optics of a Unitron refractor. "You can take them home and look at them. Make measurements," he added.

We showed him the Unitron Astrocamera 220. It's a lightweight camera designed to fit onto the eyepiece holder and uses the telescope objective as one of its principal optical elements. Its capabilities astound even today's star-gazers.

With a certain amount of pride, Copernicus told us that the earth revolves around the sun. "So do the planets," he stated firmly, perhaps expecting an argument from us. "But how do you follow those planets with your camera as they

move and the stars as they *seem* to move, eh?" Copernicus demanded.

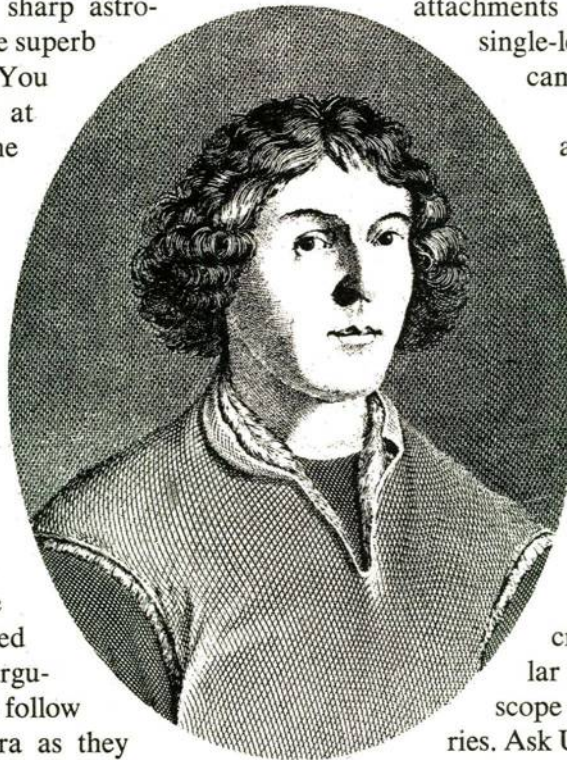
With Unitron's rock-solid mounts and precision gears for butter-smooth movement, we replied.

"Do you have to use a Unitron camera with a Unitron telescope?" Copernicus asked, peering into its finder. Not at all, we told him. With Unitron attachments you can use virtually any single-lens reflex camera, or any view camera with ground-glass focusing.

And there's nothing better, we added, than a refractor for astrophotography.

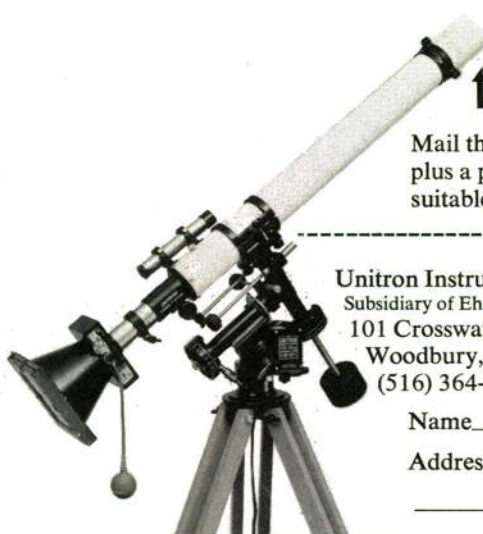
When we told Copernicus that we couldn't give him a free sample without an okay from somebody, he growled something in Polish we didn't quite catch. "Oh well," he said, "then just send me a photograph of my favorite moon crater," and left.

We didn't ask him which one. But you can take your own photos of your favorite craters, planets, nebulae, and solar phenomena with a Unitron telescope and astrophotography accessories. Ask Unitron about them.



Now we want to hear from you.

Mail the coupon and we'll send you a complete catalog, plus a portrait of our visitor, Nicolaus Copernicus, suitable for framing.



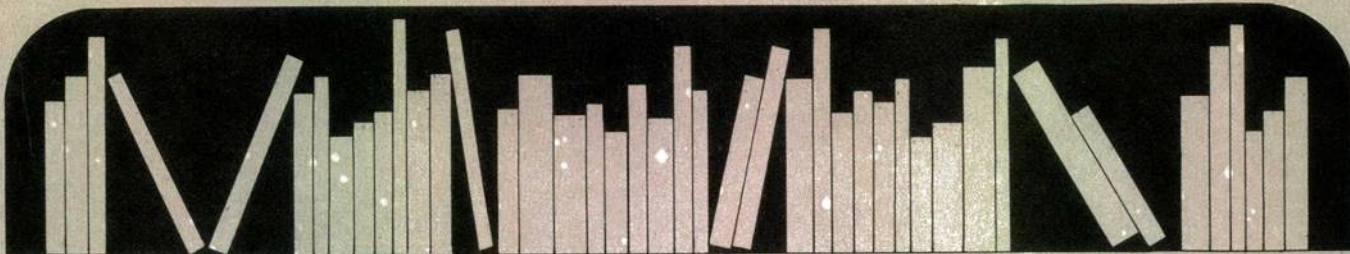
Unitron Instruments, Inc. Dept. A-10
Subsidiary of Ehrenreich Photo-Optical Industries
101 Crossways Park West
Woodbury, N.Y. 11797 U.S.A.
(516) 364-8046.



UNITRON

The value line.

Name _____
Address _____
Zip _____

**Aviation and Space Dictionary**by ERNEST J. GENTLE and
LAWRENCE W. REITHMAIER272 pages, hardcover, \$14.95
Aero Publishers, Inc. (1976)**Illustrated Encyclopedia of
Astronomy and Space**

edited by IAN RIDPATH

240 pages, hardcover, \$16.95
Thomas Crowell Co. (1976)

The technology of space has introduced many new concepts, and many new words and acronyms to express them. Space scientists often seem to be talking in their own code, designed to be unintelligible to the average person.

These two large books will give students and space buffs some help in understanding what the secret words really mean and what space scientists are trying to say. The books are both useful but for different audiences.

Aviation and Space Dictionary deals heavily with aviation and engineering, and includes many terms which the average space buff or astronomy enthusiast would never encounter. But its coverage of space terms is often spotty as well. It will be useful to people who want to fly airplanes and spaceships.

Ridpath's **Illustrated Encyclopedia** is very well done, with fewer but longer entries on important concepts and terms in astronomy and space exploration. Its valuable index (the other dictionary does not have one) can be extremely useful if the reader is warned that a careless copy editor created a fictional historical personage named "Wernher Oberth" by misreading a reference to Hermann Oberth in the entry on Wernher von Braun. This trivial error may be one that purists delight in spotting and gloating over, but it hardly subtracts from the overall high quality and impressive scope of the encyclopedia. *James E. Oberg.*

A House in Space

by HENRY S.F. COOPER JR.

184 pages (illus.), hardcover, \$8.95
Holt, Rinehart and Winston (1976)

The Skylab space station is history, except for the lingering concern that it may fall on somebody when it re-enters the atmosphere in 1981 or so. Skylab science data are being analyzed or have already found their way into new theories and textbooks. But Skylab was supposed to teach us how to live and work in space for long periods. What has happened to those lessons?

This delightful view of the experiences and lessons of the flight of Skylab in 1973-74 is a valuable addition to the library of every space buff. It describes the space station mission from a new angle: not the science, nor the hardware, nor the impressive records, but the people. The view is educational, entertaining, not always flattering, but continually enlightening. The title, which deals with the actual domicile in orbit, is misleading; the book is about habitability, not habitats.

And from that point of view it presents many valuable lessons for space stations and space colonies of the future. Space enthusiasts who anticipate living in a space house or space city should read this book to avoid making the same design or procedural errors which were part of America's first true space station.

There was always a shortage of wiping rags, so astronauts used dirty shirts. Better facilities for holding small machine parts during repairs will be needed. Sewing kits were sorely missed. Treadmills gave better exercise than the ergometer, but were harder to operate.

This is an absolutely unique and important view of living in space. It is not just an inside glimpse of the past; it is a blueprint for the future. *James E. Oberg.*

The Next Fifty Years on the Moon

by ERIK BERGAUST

95 pages (illus.), hardcover, \$4.96
G.P. Putnam's Sons (1974)

We all remember the first words spoken by the first man on the moon, and should not forget the last words of the last man on the moon. As Eugene Cernan climbed the ladder of the Apollo 17 lunar module in December 1972, he promised, "We'll be back."

This book is an attempt to portray that return to the moon, and to describe manned lunar exploration and exploitation over the next half century. Its theme is a moon colony: justifying it, building it, and living in it. A table of moon data at the end of the book is unintentionally reminiscent of the "what you must know" sections found in travel guidebooks.

But the book is both too optimistic and too pessimistic and narrow. One of the famous "laws" of space visionary Arthur C. Clarke says that prophets tend to be overoptimistic in the short run and underoptimistic in the long run. This is precisely the fault of this publication.

There will be no American manned flights to the moon for the next 10 years or more, no matter how eloquently Bergaust argues for them. (His arguments are hopefully not the best ones, because they are poor justifications for the cost of returning to the moon.)

Setting up meteorological stations on the moon to watch Earth weather, for example, is an archaic and impractical idea right out of the science fiction of the 1930s. Most scientists are convinced it can be done better and cheaper from space orbits closer to Earth. The moon will not be a particularly useful place for industrial processes such as the production of pharmaceuticals, since low Earth orbit offers better conditions at half the price.

Most of the book could easily have been written long before the Apollo expeditions reached the moon. Indeed, most of the illustrations are at least 10 to 15 years old, and represent outdated concepts and studies.

The vision of returning to the moon is gaining strength, but for reasons Bergaust does not mention. One of the best reasons is to use lunar materials for the construction of giant space power stations to relieve Earth's energy crisis. Nothing found in this book is relevant to that potentially practical reason for our return to the moon. It will happen well within 50 years, and the result will be a moon base and moon mines far more ambitious than even Bergaust's optimism was able to visualize. *James E. Oberg.*

The Next Fifty Years in Space by PATRICK MOORE

144 pages (illus.), hardcover, \$12.95
Taplinger Publishing Co. (1976)

The New Guide to the Stars by PATRICK MOORE

251 pages (illus.), hardcover, \$9.95
W.W. Norton & Co., Inc. (1976)

The very real, often spectacular, progress in space science, rocketry and astronautics during the past two decades provides an exciting source for speculation into the salient space events likely to command our attention in the foreseeable future.

Patrick Moore, the well-known English amateur astronomer, author and popularizer of astronomy and space travel, attempts such speculation in *The Next Fifty Years in Space*. Unfortunately, he has not been totally successful. A book of this nature is naturally fraught with the pitfalls of rapidly changing geopolitics, technological breakthroughs and numerous unforeseen variables (as Moore is quick to point out in the foreword and several places in the text). The book attempts to circumvent these potential difficulties by opting for a rather conservative view of what is likely to occur, coupled with a strong dose of past history and present capability. In fact, the majority of the text reiterates what has happened in the last 20 years in space! Certainly the arrangement of the book is not to blame; chapters are neatly sequential and encompass discrete time periods and space missions (for example, "Probes to the Inner Planets: 1975-1990" and "The Lunar Base: 1995-2000").

As exciting and tantalizing as these chapter titles sound, they lack substance. Moore seems reluctant to discuss hardware in any real detail,

and his constant historical allusions and digressions (some dating to the ancient Greeks) may only serve to annoy the reader who expects some definitive prognostication. Even the well-chosen and splendidly reproduced photographs and colorful artwork may fail to evoke enthusiasm, since they are often inappropriately placed within the text.

Despite these shortcomings, the book's general sense of logic and technical accuracy must be complimented. Moore wisely assumes there will be a moderate and continuous amount of funding for the imminent and less complex space missions, with international cooperation being the norm for the enormously sophisticated and costly Mars lander of the 2020s. However, the reference to the Soviets not yet having tested a Fractional Orbital Bombardment Satellite (FOBS) is obviously incorrect, and recent photographs beamed from the surface of Venus by Venera 9 and 10 may cast a shadow on the book's predictive validity. Only months before their successful missions, Moore wrote of the near impossibility of such a feat.

As a potentially stimulating and creative appraisal of the future, *The Next Fifty Years in Space* is a disappointment. Its true value lies in its solid, readable survey of past accomplishments and current space technology.

The New Guide to the Stars attempts to provide the relative novice with the "big picture" of stellar and galactic astronomy in a descriptive, nontechnical fashion. With the accent on practical observation, Moore has succeeded well in creating and maintaining a high level of interest.

The book's basic format is logical and coherent, moving from a purely descriptive impression of the stars into spectral types, stellar evolution, variable stars, novae and clusters. It culminates with a discussion of nebulae, galaxies, quasars and cosmological theory. This is certainly a vast amount of information to be dealt with in a mere 240 pages, but the necessary simplification of concepts is handled admirably. Only where Moore describes the nucleus of a helium atom (leaving the strong impression that it consists solely of two neutrons having a positive charge) is a truly misleading statement in evidence. Numerous line drawings and illustrations reinforce what is being said in the text; the sole exception is Lockyer's incorrect interpretation of a Hertzsprung-Russell diagram (page 96), which could easily serve to confuse rather than edify.

The reader who wishes to observe and study stars, clusters, nebulae and galaxies will find the book highly

useful and entertaining once he has waded through the periodic digressions and minilessons in the history of British astronomy. Appendices containing data on observable variable stars, clusters and nebulae are excellent, as are the partial constellation charts found in chapter five. One only wishes that a full set of seasonal star charts had been included, and with them additional guidance in selecting instrumentation for observing.

The New Guide to the Stars is highly recommended to the casual enthusiast who cannot or does not wish to delve into the complex treatments offered in a standard, sophisticated astronomy textbook. *Lawrence M. Carlino.*

Space Shuttle

prepared by LBJ SPACE CENTER

90 pages, paperback, \$3.40*
NASA (1976)

As the Space Shuttle moves from a design to a real spacecraft (flight tested this past summer), more information and publicity is coming from NASA. If this handsome little booklet is any sample of future products, the efforts will be welcome.

The Space Shuttle has many more facets than even the most dedicated space buff can yet appreciate. Copies of *Space Shuttle* were passed around to the engineers and scientists at the Johnson Space Center near Houston a few months ago, and even these space experts were amazed at the detailed information which they read for the first time.

The artwork, much of it in color, is excellent. Exterior action shots, cutaway views of important structural elements, and paintings of scientists and pilots at work in space are all included. Most of the artwork has never been published before.

The booklet tells nothing about the Space Shuttles "approach and landing," drop tests, nor does it mention that the orbiter space planes will carry such traditional names as Enterprise, Constitution, and Constellation. No discussion is given to the actual crew recruitment and training now going on.

The Space Shuttle vehicle is the sole topic of this booklet: how it works, how it is built, what it will do for science, its applications, and more. This information is in great demand, and *Space Shuttle* can satisfy that demand. *James E. Oberg.*

*Stock number 033-000-00651-9; available from Superintendent of Documents, Washington, D.C. 20402.

Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design tele-

scope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.



Dynamax® 8 8-Inch Schmidt-Cassegrain

For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications. The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in...and INCLUDED in the price! ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring. ☐ Large 8x50 finderscope has micrometer screw focusing ☐ Toggle switch with pilot light ☐ Engraved setting circles, observable from viewing position ☐ 3 eyepieces included ☐ Star diagonal, latitude adjusters, photo and textender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

\$875

Prompt shipment on both models. If you wish, phone us for delivery date.
To place your order, or request literature, write or call:

Criterion Manufacturing Company

Dept. CAS-58 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888



Dynascope® RV-6 6-Inch Newtonian

For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1 1/4" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, \$15 crating charge.

\$249⁹⁵

ASTRO-MART

Astro-Mart is a free, reader service department available only to current, paid, noncommercial subscribers; 2 ads are allowed per year. Each ad submitted must not exceed 40 words in length (including name, address, etc.). All ads are subject to editorial review for suitability. Be sure to allow 3-4 months for your ad to appear.

ASTRO-FILMS 35mm, 36-exp. rolls

New prices effective October 1

- Kodak Spectroscopic with antihalation rem-jet backing

Choose 103aF, 103aE, or 103aO \$6.19 ea.

3 or more \$5.39 ea. 5 or more \$4.59 ea.

•SO-410 (planets, moon, sun) \$2.10 ea.

•High Contrast Copy (planets, moon, sun) \$2.10 ea.

•2475 ASA 1000-4000 \$2.65 ea.

Film information included with order.

ASTROFILM 35¢ separately

P.O. Box 2731, Dept. AM Akron, OH 44301

CELESTRON TELESCOPES ON DISPLAY AND IN STOCK

E & W OPTICAL, INC.

2420 EAST HENNEPIN AVE.

DEPT. AM

MINNEAPOLIS, MINN. 55413

612-331-1187

SEND FOR PRICE LIST "A"—

Astronomy supplies and accessories

DEEP SPACE 3-D

A Stereo Atlas of the Stars

Have you ever wished you could see the familiar constellations in 3-D? DEEP SPACE 3-D adds depth to the sky, giving it a vivid texture our eyes alone fail to perceive. The entire sky is covered on fourteen 5x8 cards, each having a pair of computer generated stereo views and a reference chart. A folding desktop stereo viewer with glass lenses is included.

\$6.95 ppd.

California residents add 6% sales tax.

Foreign orders add \$1.00

David Chandler

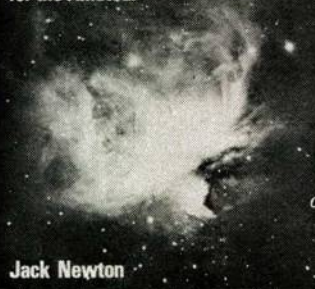
P.O. Box 309, Dept. AM

La Verne, CA 91750

Phone: (415) 327-2668

DEEP SKY OBJECTS

A Photographic Guide
for the Amateur



Jack Newton

DEEP SKY OBJECTS

A Photographic Guide for the Amateur

This guide will help you to locate and identify more than 125 galaxies, nebulae and star clusters, including the complete Messier catalog.

The 75 full-page photographs are all taken with a 12.5 inch telescope to the same one-degree scale. Easily compare the size, shape and brightness of each object illustrated.

Over 50 two-color detailed finder charts quickly indicate when and where you can see these fabulous sights.

Send \$9.50 (\$12.50 deluxe) to

GALL Publications

1293 Gerrard St., E., Toronto, Canada

FOR SALE — 8" f/8 Cave mirror and secondary, new Pancro coating; \$85.00. 6" f/5 Coulter mirror and secondary; \$35.00. 40mm airspaced f/25 objective; \$10.00. Shipping included. Contact Ray Cline, 1132 E. California - #10, Glendale, CA 91206. Phone (213) 242-8797.

FOR SALE — Telescope without mounting; 8" f/8 Coulter mirror; cardboard tube; mirror, eyepiece holders; diagonal mirror, holder. Price: \$125.00. Contact Richard E. Cormier, 6613 Independence Ave., Springfield, VA 22151. Phone (703) 256-3664.

FOR SALE — Star-Liner 8" f/8 Newtonian. Sturdy, extremely well-designed mount with 1.75" shafts, 6" circles. 3 oculars, Barlow, sun diagonal, N.D. filters, camera adapter, more. Contact Mark Erickson, 93 Estates Dr., Orinda, CA 94563. Phone (415) 254-8541.

FOR SALE — 6" Edmund reflector, clock drive, setting circles, etc. Good condition, rarely used; money needed for school. Price: \$175.00 plus shipping. Contact Bill Helgeson, 8314 Garfield S., Bloomington, MN 55420. Phone (612) 881-5376.

FOR SALE — "Exploring the Moon Through Binoculars"; "The Earth Space Sciences"; "Journey to Tranquility"; etc. Send SASE for list to Mark R. Herbst, 967 Theresia St., St. Mary's, PA 15857.

FOR SALE — 5" f/5 RFT, lens. Excellent condition; all assembled. Will sell for \$160.00 including shipping. Contact Mike Hicks, 1006 N. River St., Alma, MI 48801.

FOR SALE — C8, wedge, tripod, 4 eyepieces, 8 x 50 right angle T.P.N. finder, drive corrector, automatic tracker, sun filter, off-axis guiding, telecompressor, telextender, piggy-back mount, 2 filters, latitude adjuster, counterweights; \$1,500 plus shipping. Contact Keith Krueger, 6909 W. Armour Ave., Milwaukee, WI 53220. Phone (414) 281-6904.

FOR SALE — Molded cowhide eyepiece case (1-1/4"); lined, zippered, belt flap. 4 lined clips; takes Barlow. Price: \$25.00. Write Bert Leifer, 226 E. Washington Blvd., Fort Wayne, IN 46802.

FOR SALE — Timefram time lapse photography kit. Interval varies from .5 sec. to 5 min. Never used; new, \$150.00. Price: \$100.00 f.o.b. Contact Arthur W. May, 9197 Broadlands Ln., Nokesville, VA 22123. Phone (703) 754-4933.

FOR SALE — 6" f/8 Newtonian, Cave optics, Novak focuser, 1-5/8" shafts on very stable mount, 3 eyepieces, camera mount with OM-1 ring, Barlow, accessory case. Price: \$175.00. Contact Robert Schmall, 1314 N. 63rd Ct., Wauwatosa, WI 53213. Phone (414) 257-1922 evenings.

FOR SALE — Texas Instruments SR-52 card programmable calculator. Math, finance, statistics libraries. 2 chargers, extra cards, all manuals. Like new; \$150.00 or best offer. Write Ed Seeley, Dept. of City Planning, 2 Lafayette St., New York, NY 10007.

"Invaluable . . ."

"Congratulations on providing me with one of the finest correspondence courses I have ever received. I found the lessons thorough but easily comprehensible. I am looking forward to starting your Astronomy II course, since I found the Astronomy I course invaluable."
—Edward J. Kashuba, Bradenton, Florida

You will be amazed at how easy it is to learn more about astronomy with Coast Navigation School's streamlined home study courses designed especially for amateur astronomers. Call or write today for our free course catalog.

CELESTRON Schmidt-Cassegrain and UNITRON refractor telescopes available.
Special prices on course/telescope combinations.



Coast Navigation School of Astronomy
Dept. 5352
Santa Barbara, CA 93102 | 805 963-7837

I'm interested! Please send me your free school catalog.

Name _____

Address _____

City _____

State, Zip _____

FOR SALE — New home built 10" Cassegrain, equatorial mount, clock drive. Price: \$650.00. Request pick up or payment for shipping. Will send information to serious prospects. Write David Schultz, 5931 Hilgard Pl., St. Louis, MO 63109.

FOR SALE — Celestron 50mm f/1 Plossl 2" eyepiece; \$50.00. R.T. Little solar filter for C-8; \$20.00. Optica adapter (2"-1-1/4"); \$7.00. Set of Optica b/c mount levelers wanted for C-8 tripod. Contact Ron Adams, 34586 Chope Pl., Mt. Clemens, MI 48043. Phone (313) 791-4546.

FOR SALE — Complete set of ASTRONOMY (Vols. 1 through 4). Mint condition; kept in ASTRONOMY Volume Files. Sell as complete set only. All offers answered. Send bids to Norman C. MacPhail, 11 Del Mesa Carmel, Carmel, CA 93921.

FOR SALE — Criterion 8" Dynamax with all standard accessories. Excellent condition. Price: \$795.00; you pick up. Contact David Nicholson, 133 Hills-Miller Rd., Delaware, OH 43015. Phone (614) 363-1539.

FOR SALE — Back issues of ASTRONOMY: July 1974 to July 1976. Excellent condition; best offer. Write Michael Dunn, 23 Scarlet Oak Rd., Levittown, PA 19056.

FOR SALE — Sears 60mm altazimuth mount refractor, 3 eyepieces, erector, Barlow, extras. Will throw in more extras if you pick up. Price: \$100.00. Contact Brent L. Bates, 4769 N. Brooke Dr., Marion, IN 46952. Phone (317) 662-9204 between 8 a.m. and 9 p.m.

FOR SALE — Unitron 4" refractor; UniHex; eyepieces; mounted 2.4" guide refractor with aperture filter, etc. for solar viewing; accessories. Brand new; used only twice. Price: \$900.00 firm, including shipping. Contact Julius L. Benton Jr., Box 60, Clinton, SC 29325. Phone (803) 833-1232, ext. 65.

Astronomical Instruments Tailored To Your Needs



BY COLE ENERGY SYSTEMS

All the latest CELESTRON and MEADE equipment stocked, with demonstrations by appointment. Some stock still available at pre-August prices. Pre-payment required. We offer custom design of instruments and accessories by professionally qualified personnel. Write for FREE brochure listing lowest prices in industry.

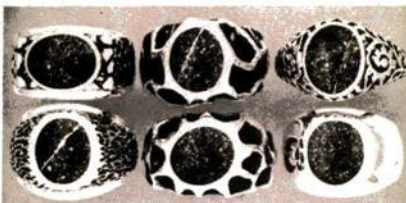
BankAmericard or Master Charge financing available.

COLE ENERGY SYSTEMS

Dealers for CELESTRON and MEADE
P.O. Box 1214 • Maitland, FL 32751
Phone (305) 831-3809

METEORITE RINGS

Now in 14Kt. Gold or Sterling Silver



The only rings on Earth with stones from outer space. Only \$28.50 in sterling silver or \$85.50 in 14kt. gold. For free brochure write:

HOUSE OF RINGS

P.O. Box 6127, Dept. AM,
Kansas City, MO 64110
Phone: 816-363-2002

NOW AVAILABLE GOTO AND CARTON REFRACTING AND REFLECTING TELESCOPES

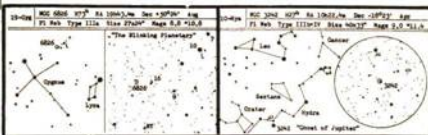


Accessories:
Moon & Sun Camera,
Guide Telescopes,
Eyepieces,
and many more.

Send for free catalogue
or call:

(914) 337-4085

R.V.R. OPTICAL
P.O. Box 62 Dept. AM
Eastchester, NY 10709



INDEX CARD FINDER CHARTS

Made especially for use at the telescope!

SET I — THE MESSIER OBJECTS \$6.50
SET II — THE FINEST NGC OBJECTS \$6.50
SET III — THE FINEST DOUBLE STARS \$6.50

75. 3X5 CHARTS PER SET.

KODAK SPECTROSCOPIC FILM

35-mm., 36-ex. rolls with Rem-jet backing.
Choice of 103a-E, 103a-F, 103a-O, \$6.25 ea.
3 or more \$5.50 ea., 6 or more \$4.75 ea.
SO-410, \$2.15; Astro-Films Booklet — \$1.00

Astro Cards*

P.O. Box 35, Natrona Heights, Pa. 15065

Observatory Domes
to highest professional standards.
Aluminum, Fiberglass, Steel
+

Planetarium Projection Domes
+

Exclusive Sales Agents
in the United States and Canada
for the incomparable Zeiss Planetarium.



371 Commerce Park Dr. / P.O. Box 885 / Jackson, MS 39205
Phone (601) 982-3333



DYNAMAX 8[®] OWNERS

CUSTOM-ENGINEERED ACCESSORIES FOR YOUR SCOPE TO ENHANCE ITS OPERATION

● Portable rugged lightweight tripod with fingertip latitude adjustment. Includes the famous POLARIS POINTER™ system. No need to level the tripod or know your latitude to find the celestial pole.

● NO-DU™ CAPS. Removable molded black flock-lined antideicing caps. Heated or unheated models available.

● 50-mm. 7-power right-angle finder. Large prism elbow diagonal. Six-degree field. Mounts in present finder mounting rings 1-1/4". Focusable eyepiece.

● Slow-motion manual declination control. Five times finer adjustment than original equipment.

● VELVET TOUCH™ helical eyepiece focuser. Overcomes mirror focusing image shift.

● TELE-COMPRESSOR. Reduce your photographic exposure time to 25%.

● Coaxial mount for 35-mm. cameras. Mounts with helical stainless-steel ring clamp to rear casting.

● SOLAR-SKREEN™ and CELL ASSEMBLY. Famous patented (USA #3,897,140) sun filter. SAFE because it keeps all the heat out of the scope.

Send for FREE Dynamax 8 catalog today

Money-back guarantee
on all products.



ROGER W. TUTHILL, INC.
Box 1086A, Mountainside, N.J. 07092
Telephone: 201-232-1786

CELESTRON 8, 14 SUPER SPECIAL FOR OCTOBER

C-8 \$777.00

SAVE \$218.00

C-14 \$3850 T.C.C.

SAVE \$145.00

OR

Purchase a C-8, Tripod, Wedge at factory prices and we include at no charge the following accessory packages.

A Free 8" Celestron Solar Filter and a precision collimation kit. A \$265.00 Value

OR

A Free complete set of Brandon parfocal orthoscopic eyepieces in a deluxe carrying case. A \$275.00 Value.

OR

A Free DOAA AD-2 drive corrector and a Gieseler declination drive and an Astro-Physics 1000mm full frame telecompressor. A \$220.00 Value.

Purchase a C-14, tripod, and wedge at factory prices and we include free, a Celestron 10x70 finder, a full range heavy duty latitude adjuster, and a precision collimation kit — A \$275.00 Value.

New, easy to use Celestron precision collimation kits

C-5 \$30.00

C-8 \$40.00

C-14 \$50.00

C-8 latitude adjusters - \$17.00

C-14 5/8" harden steel latitude adjuster - \$49.95

Free Shipping on most items in U.S.A.

750mm, 1250mm telephotos, Edmund Astroscans, C-5, C-8, C-14 telescopes and Schmidt cameras in stock.

NEW FOR ASTROSCAN OWNERS.

Ruggedize your scope with a thick anti-shock rubber jacket.

Now Dealers for Edmund and Gieseler Electronics too.

Open 9:00 AM to 3:00 AM (on clear nights)



Order now from
B.E. MEYERS & CO.
2717 200th Ave. S.E.
Issaquah, Wash. 98027
(206) 392-2237

FOR SALE — Edmund 6" reflector, 3 eyepieces, Barlow, setting rings, clock drive, pedestal stand; camera holder. Perfect condition. Original instructions and literature. Price: \$230.00 plus freight. Contact David O. Bach, 420 E. Prospect, Ottawa, IL 61350. Phone (815) 433-2779.

FOR SALE — Nikkormatt ELW system; lenses (50mm f/1.4, 105mm f/2.5); autowinder; skylight, UV filter; camera, lens cases; lens hoods; shutter, cable release; eyecup, camera strap; Nikon books, etc. Never used. Best offer over \$800.00. Contact Ron Barnell, R.D. #2, Amsterdam, NY 12010. Phone (518) 887-2993.

FOR SALE — Back issues of ASTRONOMY. For list, send SASE to David Branner, 21 Claremont Ave., New York, NY 10027.

FOR SALE — Sears 3" refractor, equatorial mount, slow motion, many extras; \$180.00. Tasco 4.5" reflector, equatorial pier mount, 50mm guidescope, slow motion, camera adapter, extras; \$125.00. Contact Randall Tragni, 105 Topeka Ave., San Jose, CA 95128. Phone (408) 292-7495.

FOR SALE — Celestron 8 with clock drive, wedge, tripod, 3 eyepieces (12mm, 25mm, 40mm). Price: \$800.00. Contact William Vander Kooi, Rt. 1, Pecatonica, IL 61063. Phone (815) 247-8409.

FOR SALE — 10' fiberglass Observa-Dome with complete fittings and 12-1/2" Cave Newtonian reflector with all accessories. Excellent condition. Price: \$4,000.00. Contact F. Wilson, 14036 Mint Trail, San Antonio, TX 78232. Phone (512) 828-8484 or 494-6739.

FOR SALE — Edmund products. Barlow (#40,477); \$6.00. Camera holder (#70,162); \$11.00. Star diagonal (#50,247); \$10.00. Pedestal with post cap (#85,142); \$20.00. Mounted Herschel wedge, \$5.00. Contact Danny Sagstetter, 4889 Kingshill Dr., Apt. 118, Columbus, OH 43229. Phone (614) 885-5109.

ASTRONOMY Volume Files

Custom, designed magazine Volume Files are now available for ASTRONOMY subscribers. These sturdy, washable cases have a rich brown leatherette finish, and ASTRONOMY is embossed in elegant gold on the spine. Each case holds 12 80-page issues (one complete year), and comes with a slip of gold signature foil to fill in volume number and year. Keep the World's Most Beautiful Astronomy Magazine beautiful year after year with this impressive addition to your library.

Only \$4.95

\$4.95 each or 3 for \$14.00, 6 for \$24.00



To order, simply fill in and mail the attached coupon today!

Use this address **ONLY** for Volume File orders and correspondence regarding them.

ASTRONOMY Volume Files
P.O. Box 5120
Philadelphia, PA 19141

Enclosed is \$_____ in payment for the following ASTRONOMY Volume Files:

_____ 1 for \$4.95 _____ 3 for \$14.00 _____ 6 for \$24.00

Name _____

Address _____

City _____

State _____

Zip _____

U.S.A. orders only. Allow 3 weeks for delivery.
Full money back guarantee.

CELESTRON UNITRON VERNONSCOPE UNIVERSITY OPTICS ASTRO-PHYSICS DOAA DEL N. WOODS

Telescopes, binoculars,
telephoto lenses,
spotting scopes, oculars,
drive correctors, cameras,
barlows, filters,
latitude adjusters,
books & atlases

It is our continuing goal to offer the finest astronomical instrumentation available combined with the consultation, demonstration, and service that is important to your satisfaction.

Most items delivered from stock.
Call, write, or drop in

DAVID A. POTTER
723 Cedar, Dept. A
Sandwich, IL 60548
(815) 786-8168



FOR SALE — Criterion RV-6 as advertised. New in November 1976. Price: \$180.00. Contact Bernie Aken, One Slate Hill Dr., Poughkeepsie, NY 12603. Phone (914) 462-3101.

FOR SALE — 3" Unitron refractor, altazimuth mount, 5 eyepieces, star diagonal, erecting prism, Barlow, wooden cabinet. 1 year old; excellent condition. Price: \$290.00. Contact Edward Lenahan, 100 E. 30th St., Bayonne, NJ 07002. Phone (201) 436-4611.

FOR SALE — Excellent 6" f/15 Cassegrain, Coulter optics, Novak parts, 24" x 7" O.D. aluminum tube, Edmund heavy duty 60" pedestal mount with clock drive. Price: \$175.00 plus shipping. Contact Danny Sagstetter, 4889 Kingshill Dr., Apt. 118, Columbus, OH 43229. Phone (614) 885-5109.

FOR SALE — 16" f/6 Cave tube assembly with fully rotating rings, 2" focuser, enhanced coatings. Price: \$1,500.00. Contact John A. Vogt, 57 Conklin Ln., Huntington, NY 11743. Phone (516) 427-6210.

TRADE — 30 back issues of ASTRONOMY (November 1974 through August 1977 — missing February, June, July, August 1976) for telescope. Will pay both shipping charges. For further details, contact Jerry Blackwell, 6804 Eastbrook Ave., Baltimore, MD 21224. Phone (301) 633-5871.

WANTED — Accounts from persons who have observed or experienced any kind of unusual phenomena or event (especially if about life after death). For personal use. Write Joseph Zito, 104 Brookfield Rd., Riverside, RI 02915.

WANTED — Old tape recordings of radio and TV conversations, broadcasts of space related endeavors. Reel to reel or cassette on Goddard, Mercury, Ranger, Gemini, Surveyor, Apollo, etc. Also old books. Write Robert Fletcher, 341 Conifer Ct., Walnut Creek, CA 94598.

SECONDARY HOLDERS AND SPIDERS



Newtonian diagonal holders in stock for most sizes. Lightweight aluminum construction with continuous retaining rim — no tabs to increase diffraction. Carefully designed to prevent strain on optics. Spiders feature high tensile strength stainless steel vanes.

ALUMINIZED ELLIPTICAL DIAGONALS

Fine annealed Pyrex. Listed by minor axis size.

1.30" .. \$8.00 1.52" .. \$11.50 1.83" .. \$13.50
2.14" .. \$16.50 2.60" .. \$19.50 3.10" .. \$29.95

Write For Free 24 Page 1977 Catalog

Includes valuable information on how to determine accurately the proper size diagonal for your needs.

13 Newtonian mirror mounts, 4-1/4" to 16"
22 Diagonal holders, 1-1/4" to 4-1/2" minor axis
24 Spiders, for tubing from 5" to 24"
8 Rack and pinion focusing mounts

Also extensive selection of Cassegrain mirror mounts, Cassegrain secondary holders, tube counterweights, ring mounts, star diagonals, guide telescopes, illuminated and regular cross-hair eyepieces, information booklets and many other telescope items.

KENNETH NOVAK & CO.

Box 69A

Ladysmith, WI 54848

Phone: 715-532-5102

A STAR IS BORN



Introducing the NEW, COMPACT, LIGHT-WEIGHT 'STARGAZER' 6" f4 RFT. This unique and versatile telescope can be hand-held, equatorially mounted, used as a finder or guide scope on a larger telescope. Prepare yourself for SENSATIONAL views of the Universe — galaxies, nebulas, comets, stars and the moon stand out CLEAR and BRIGHT for breathtaking cosmorama.

The 6" f4 primary mirror has a 24" focal length $\pm 1/8$ wave parabolic. Fiberglass tube is 25" long. Complete telescope weighs 7 lbs. The rack and pinion focuser is one of the best available. Telescope available with standard 1-1/4" focuser with either 25mm Kellner (2 degree field) OR 20mm wide field Erfle (2-1/2 degree field). Telescope may also be ordered with 2" focuser and 2 inch 32mm Erfle (3-1/2 degree field).

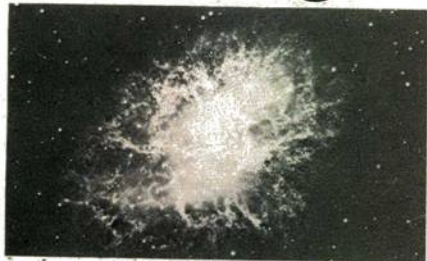
STARGAZER 6" RFT tube assembly w/o eyepiece. \$119.95 ppd
STARGAZER 6" RFT tube assembly w/25mm Kellner eyepiece. 129.95 ppd
STARGAZER 6" RFT tube assembly w/20mm Erfle eyepiece. 149.95 ppd
STARGAZER 6" RFT tube assembly w/32mm Erfle eyepiece. 199.95 ppd

ABOVE PRICES EFFECTIVE THROUGH SEPTEMBER 30, 1977 AT WHICH TIME PRICES WILL INCREASE BY \$20.00.

Send \$1.00 for our complete CATALOG 77a showing high quality, lightweight and portable telescopes and telescope accessories to:

STAR INSTRUMENTS
P.O. Box 1606, Dept. A
Costa Mesa, California 92626
Telephone: (714) 540-8729

15 Billion Years in the Making!



FULL-COLOR POSTERS

SLIDES, POSTCARDS, MAPS, PRINTS
Over 700 items available.

- THE LARGEST SELECTION
- THE HIGHEST QUALITY
- THE LOWEST PRICES

A single source for space visuals from

- Hale Observatories
- Lick Observatory
- NASA

Substantial discounts on quantity orders!

Write Dept. A for our catalog and free postcard.

HANSEN PLANETARIUM

15 South State Street Salt Lake City, Utah 84111



FOR AN UNBEATABLE NO-NONSENSE DEAL . . .

you'll want to buy your new Celestron telescope from ORION Telescope Center.

No need to settle for a pre-selected package just to get a low price. Select only the accessories you want — and get a low price you can afford.

AccuTrack® The most complete line of electronic telescope accessories.

Even if you're not in the market for a new Celestron, be sure to check our line of famous **AccuTrack®** Drive Speed Controls, Automatic Tracking Units, Porta-Pak rechargeable battery power supplies, DC power inverters, and much more.

Feel free to telephone or write if you have any questions about telescopes or accessories.

FREE ILLUSTRATED CATALOG



ORION Telescope Center

A division of Gieseler Electronics

303 Potrero #7-C, Santa Cruz, CA 95060 (408) 423-1984

ASTRONOMY

Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly; issues not listed are depleted.

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

\$1.50 per copy

U.S. — Add \$1.00 per order

Canada/Mexico — Add \$2.00 per order

All Other Foreign — Add \$2.50 per order

Vol. 1, No. 1 - August 1973	Available	Vol. 4, No. 9 - September 1976	Available
Vol. 2, No. 7 - July 1974	Short Supply	Vol. 4, No. 10 - October 1976	Available
Vol. 3, No. 5 - May 1975	Available	Vol. 4, No. 11 - November 1976	Available
Vol. 3, No. 6 - June 1975	Available	Vol. 4, No. 12 - December 1976	Available
Vol. 3, No. 7 - July 1975	Available	Vol. 5, No. 1 - January 1977	Available
Vol. 3, No. 8 - August 1975	Available	Vol. 5, No. 2 - February 1977	Available
Vol. 3, No. 9 - September 1975	Available	Vol. 5, No. 3 - March 1977	Available
Vol. 3, No. 10 - October 1975	Available	Vol. 5, No. 4 - April 1977	Available
Vol. 3, No. 11 - November 1975	Available	Vol. 5, No. 5 - May 1977	Available
Vol. 3, No. 12 - December 1975	Available	Vol. 5, No. 6 - June 1977	Available
Vol. 4, No. 2 - February 1976	Available	Vol. 5, No. 7 - July 1977	Available
Vol. 4, No. 3 - March 1976	Available	Vol. 5, No. 8 - August 1977	Available
Vol. 4, No. 4 - April 1976	Available	Vol. 5, No. 9 - September 1977	Available
Vol. 4, No. 5 - May 1976	Available	Vol. 5, No. 10 - October 1977	Available
Vol. 4, No. 6 - June 1976	Available	Vol. 5, No. 11 - November 1977	*NYP
Vol. 4, No. 8 - August 1976	Available	Vol. 5, No. 12 - December 1977	*NYP

*Not Yet Published

Please allow at least four (4) weeks for delivery.

Rosemary L. Pickart
ASTRONOMY Magazine
411 E. Mason, 6th Floor
Milwaukee, WI 53202
(414) 276-2689

WANTED — Standard or duplex Questar in top condition; preferably wide field. Please air mail price and list of accessories, if any, to William T. Welch, APDO 787, Alajuela, COSTA RICA, CENTRAL AMERICA. Phone 41-33-29 nights or 41-24-64 days.

WANTED — Contact with persons interested in communicating on topics such as astronomy and other science related fields via 6m SSB amateur radio. For schedules, write John M. Zupko, 144 Edmund St., Trenton, NJ 08610.

WANTED — September, October, November, December 1973 issues of ASTRONOMY. Will pay up to \$12.00 for all four. Write Joseph T. Schmidt, 22431 West St., Rt. 579, Curtice, OH 43412.

WANTED — Regular correspondence with persons having telescopes that are very interested in astronomy. Write Carle Turek, 1723 Royal Oak S.W., Wyoming, MI 49509.

WANTED — Contact with persons in my area seriously interested in astronomy. I am 25, have 4-1/4" reflector, and am interested in many phases of astronomy. Contact Edwin Canada Jr., 115 Daniel St. S.W., Decatur, AL 35601. Phone (205) 350-1468.

WANTED — Back issues of ASTRONOMY: September, October, November, December 1973. Please state condition, price. Contact Thomas Arcidiacono, 1121 Fairview Rd., Hagerstown, MD 21740.

WANTED — 35mm slides from "Star Trek" (obtained from Lincoln Enterprises) of the "Doomsday Machine". Wish to trade. Write Joseph Zito, 104 Brookfield Rd., Riverside, RI 02915.

WANTED — Correspondence with persons and/or clubs involved in astronomy and/or amateur astronomers in the Tulsa-Northeastern Oklahoma area. Would like to join a club. Write Al Record Jr., P.O. Box 72, Sapulpa, OK 74066.

WANTED — Correspondence with females (in your 20s) interested in astronomy and nutrition. Write Byron E. Bemis, RFD #4, West Walnut Street Rd., Greencastle, IN 46135.

WANTED — Correspondence with anyone, any age (I'm 25) interested in astronomy, country life. Will answer all letters. Write Larry Fuller, R.R. #1, Fingal, Ontario, CANADA NOL 1K0.

WANTED — January 1976 (Vol. 4, No. 1) issue of ASTRONOMY. Must be in good condition; will pay good price. Write Roger Howard, Rt. 3, Opp, AL 36467.

WANTED — Reports of UFO sightings. Questionnaire will be sent. Write Larry Marso, c/o UFO Investigation Center, P.O. Box 24215, San Jose, CA 95154.

WANTED — Intelligent correspondence with persons (preferably females) about relativity, quantum mechanics and/or philosophy (John Milton, Kant). Write Dan Murphy, 1016 Cottage Ct., Warren, OH 44483.

WANTED — Progressive new astronomy group desperately needs persons interested in sharing both financial costs and scientific rewards of operating an observatory in central Indiana (Indianapolis area) with a 12-1/2" Newtonian. Call Ronald F. Nye, c/o Schneider Engineering Corp. Phone (317) 898-8282 days.

INFORMATION WANTED — Would like to know your 10 science fiction favorites in the following categories: 1) movies; 2) books; 3) short stories; 4) authors; 5) TV shows; 6) characters. For results, send SASE to Perry G. Moore, 1326 Burton Valley, Nashville, TN 37215.

ANNOUNCEMENT — Amateur astronomy night course at Moorpark College starts Oct. 13. Course will be for both advanced and beginning enthusiasts. For details, contact Moorpark College Community Services, 7075 Campus Rd., Moorpark, CA 93021. Phone (805) 529-2321.

ASTRO-NEWS

Latest News From the World of Astronomy

Update on Uranus' Rings

Particles forming the rings of Uranus are locked into their orbits by the combined gravitational effects of the planet's three largest satellites, according to Cornell University astronomers S.F. Dermott and Thomas Gold. Their analysis suggests that Uranus has six rings, rather than the five originally announced by Cornell astronomer James Elliot after an occultation by Uranus of the star SAO 158687 on March 10 (see Astro-News, May 1977). The star was obscured five times before it passed behind Uranus, and five times after it emerged. But the outer occultation on each side of the planet was caused by two different rings which only partly circle Uranus, according to Dermott and Gold.

Unlike Saturn's rings, which are a wide band of orbiting particles with narrow gaps swept by the gravitational effects of the satellites, the rings of Uranus are narrow bands separated by much wider gaps. So-called *resonances*, in which rings, particles and satellites return to a given position after an exact number of orbits, are responsible for the concentration of material into such narrow lanes.

Dermott's and Gold's theory says that satellites must work in pairs to produce a Uranian ring. They propose that the rings are caused by combined effects of its satellites Ariel and Titania, and of Ariel and Oberon, which, they predict, will form a total of six rings.

But conjunctions between the perturbing satellites cause the particles to congregate at one particular part of the ring. Therefore, the rings need not be complete, but may be crescent shaped. This seems to be the case for at least the two outer rings.

Elliot had noted that the outer occultations of the star SAO 158687 on either side of Uranus were not symmetrical, and therefore assumed that the outer ring was elliptical. Instead, Dermott and Gold now say that these two occultations were caused by two different and incomplete rings.

The orbits of Ariel, Titania, and

Oberon are themselves close to resonances like those of the rings. Dermott and Gold suggested that Ariel may have been formed from a ring which collected into a complete body, while the remaining rings were prevented from coalescing because they lie inside or dangerously close to Roche's limit.

The Cornell astronomers note that there is a tendency for close commensurability of the orbital periods of the

planets as well as of the satellites of Jupiter, Saturn and Uranus. Therefore, three-body resonance seems to have had a major role in the evolution of the solar system. In the ring system of Uranus, we may see the process by which the planets and their satellites grew from the nebula around the sun 4.6 billion years ago. ☛

NASA Aids Cancer Research

Every year thousands of women are subjected to screening procedures for breast cancer which use potentially harmful x-rays. NASA engineers are working on an experiment that would predict if a woman is likely to ever develop cancer, and to detect such growth in its early stages.

Repeated x-rays have often been considered necessary because developing stages of breast cancer are sometimes undetectable by doctors who examine the x-rays. This makes early diagnosis more difficult, and sometimes allows cancerous tissues enough time to multiply until massive surgery is the only solution.

For two years, engineers in the Data Analysis Facility at Kennedy Space Center have been working on the problem. The experimental process involves techniques similar to those originally developed to analyze imagery transmitted from Landsat satellites.

This experimental technique for early cancer detection is a product of x-ray enhancement — the ability of computers to enhance, or make more visible, information from x-rays not ordinarily detectable by the human eye.

Trained radiologists who examine x-rays work with a built-in handicap — the human eye. The eye has difficulty in detecting small density changes or changes in the gray shades of the intensity spectrum's upper density region. Most x-ray data is within this upper density region.

The human eye — even the most highly trained one — can detect about 32 different shades of gray at best. For radiologists, this means that much of the information contained on an x-ray is invisible to them. Therefore, there's a need for a method of putting these undetectable shades of gray into better perspective — enhancing them so they are easily visible.

This is where the Data Analysis Facility stepped in with its General Electric "Image 100" multispectral image analyzer. It is a computer controlled system which extracts and classifies information about an image much better than can be done by human means.

Shades that were previously invisible to a doctor's eyes are now analyzed in much more detail. This makes significant information visible much earlier, improving prospects for an earlier diagnosis.

The special optical tool that begins this process is called a *microdensitometer*. Far superior to the human eye, it can detect 256 shades of gray with great accuracy.

The microdensitometer scans a photographic image such as an x-ray, and then puts the information into computer language. The information is fed into the Image 100 with instructions to enhance the low visibility gray shades. After classifying the gray

Cancer continued on page 68

Sequence Links Quasars, Radio, Normal Galaxies . . .

An evolutionary sequence linking quasars, radio galaxies and normal galaxies has been outlined by two Italian radio astronomers. The model builds on the optically-established point that quasars are actually the brilliant centers of giant elliptical galaxies, and the model's results fit the observed distribution of quasars and radio galaxies in the universe. The fact that there were more of these energetic objects around in the past than there are now is one of the prime pieces of evidence from which astronomers conclude that the universe as a whole is evolving.

Astronomers G. Grueff and M. Vigotti (of the Institute of Physics at the Università degli Studi in Bologna) began by asking what a quasar such as 3C 47, which has a classic double radio structure, would look like if its brilliant optical nucleus were switched off. The answer is that the strong central emission would no longer conceal the image of the underlying galaxy, and 3C 47 would be called a radio galaxy.

To extend this insight into a viable model, Grueff and Bigotti collected optical identifications and redshift measurements of catalogued radio sources. From these observations, they've proposed that about 13 billion years ago, corresponding to a redshift of about 2.5, most or all giant elliptical galaxies in our universe lit up to become glaring quasars with associated radio sources. The optical and radio emission is powered by the superactive nucleus of the galaxy.

According to the astronomers, when a quasar turns off optically, its radio emission can live on for perhaps billions of years as a fossil relic, with a giant elliptical galaxy at its center which becomes visible once the quasar glare dies down. We call such an object a *radio galaxy*. But since its central energy source switched off with the death of the optical quasar, the radio galaxy must also slowly fade and die, eventually leaving a radio-quiet giant elliptical. The length of time a radio galaxy lives after the quasar stage is inversely proportional to its energy: The most powerful radio galaxies radiate their energy away the quickest. This explains why faint radio galaxies do not show evolutionary changes, while powerful ones do.

Such a model predicts approximately the right ratio between quasars and galaxies at various times in the past, and accounts for the differing numbers of radio sources at increasing dis-

tances, as observed by radio astronomers. The unifying model is also strongly supported by the demonstration made not long ago that quasars, radio galaxies, and normal galaxies can be fitted onto a Hubble diagram (plot of redshift against distance) as though all three types of objects were part of an evolutionary sequence.

Grueff and Bigotti have not speculated on the actual energy sources at the centers of quasars — although for several years, it has been thought that massive black holes could fit the bill. Theorist J.G. Hills of the University of Michigan proposed in 1975 that a black hole at the heart of a galaxy could grow by the influx of matter to a mass of a million suns or more, at which stage it would have massive tidal effects on nearby stars, pulling them to pieces and sucking in the gas. A strongly radiating dust and gas cloud would be formed around the black hole, with a diameter of a few light-weeks — the size of the brilliantly radiating heart of a quasar.

The black hole would continue to disrupt stars, feed on the products, and emit radiation equivalent to the output of millions upon millions of suns for over a billion years (the exact time scale would depend on the density of stars around it). Eventually the black hole would get so big that it would

swallow whole stars without breaking them up; when this stage is reached, the radiation output of the black hole cuts off. This would be equivalent to the death of the optical quasar predicted by the Italian astronomers.

Hills' ideas have recently been re-examined by astrophysicists P.J. Young, G.A. Shields and J.C. Wheeler of the University of Texas at Austin. They've found that the brightest quasars (with a calculated mass of 300 million suns, and luminosities over a million million times that of the sun) can be explained by accretion of matter onto a rapidly spinning black hole at the object's heart. This *black tide* model predicts that quasar luminosity will rise to a peak before rapidly falling away — exactly the behavior required by the Italian evolutionary model.

One problem noted by the Texas group is that the number of stars in orbits which intersect the black hole may become strongly depleted before the quasar's maximum theoretical output is reached. However, this problem should not be insuperable with further investigation. A unified evolutionary sequence from quasars to normal galaxies, with giant black holes supplying the relevant energy source, would solve one of the major controversies in astrophysics today. ☛

. . . and Chemicals Involved

Astronomers trying to explain the evolution of galaxies (starting with their present understanding of the stars) are working from "the partly-known toward the almost-unknown", according to Prof. Bernhard Pagel of England's Royal Greenwich Observatory. Several distinguished astronomers attempted to explain the chemical evolution of galaxies at a recent meeting of the Royal Astronomical Society.

The chemical evolution referred to is the gradual conversion of the basic hydrogen of the universe (together with a little helium and deuterium) into heavier elements. This process is now thought to take place chiefly inside stars, where nuclear reactions synthesize the heavy elements which are scattered by stellar winds and supernova explosions to provide a richer mixture of elements for each succeeding generation of stars.

With sweeping disregard for details, astronomers generally lump all the heavy elements (excluding hydrogen, helium and deuterium) together as *metals*, but then explain that by *metals* they mean chiefly carbon, nitrogen and oxygen. This semantic confusion aside, there seem to be some real problems in explaining how these metals accumulate in stars — problems which may be resolvable.

Pagel cited the so-called *G dwarf* problem, which states that old dwarf stars of type G have a greater enrichment of heavy elements than they should have — if you assume the galaxy really started out as a cloud of hydrogen with a lacing of helium and deuterium. Most G dwarfs, regardless of age, have more or less the same metal abundances — as far as we can tell within the range of errors which

Chemicals continued on page 68

Mars After Viking?

BRIEFS

The success of the two Viking missions and their implications about geological and protobiological processes on Earth-like planets have spurred NASA discussions of possible new missions designed to go back to Mars for a closer look.

From the day of the first Martian landing, scientists have excitedly discussed the possibilities of a vehicle with Vikinglike instruments, but able to roam the Martian surface (see *Astro-News*, February 1977). One type of mission being considered, therefore, is the so-called *rover*. Although the Martian boulders and dunes look like formidable country to cross, engineers at the Jet Propulsion Laboratory in Pasadena, Calif., have been studying such vehicles ever since they were first proposed for lunar missions, and say that the Martian surface can be crossed by remote control. They have also developed a camera system, about 1 x 1 x 6 inches and shock-tested in 1,000 g (gravity) impacts, that could be used on such a rover. Other analytical instruments, such as rock analyzers, are being tested.

A simpler and cheaper type of vehicle for exploring Mars is called the *penetrator*. A penetrator is a torpedo-like probe with a detachable finned section at the rear. Parachuted to low altitude, it is dropped vertically onto the ground. The finned section catches at the soil surface and protrudes, but the forward section can penetrate several yards into solid rock and tens of yards into sand or dust. The forward section carries instruments and is connected to the aft by wire; the aft section has an antenna and beams the information from the buried instruments to a spacecraft for relay to Earth.

Such penetrators have been built and

tested with shockproof instruments on Earth. Typical penetrators are about six feet (two meters) long. Experiments that could be flown include seismometer, soil chemical analysis, and temperature measurement. One advantage of the system is that these instruments are automatically brought directly into firm contact with Martian soil, where we want them, instead of being mounted on a "rickety" (from the seismic point of view) spacecraft where soil samples have to be scooped and delivered.

Another advantage of the penetrator is that it is cheap; four could probably be flown on a single, low cost Mars return mission. This is advantageous because the penetrators could be deployed in widely different terrain types, such as polar ice caps and equatorial canyons — too far apart to be visited by a single rover. This strategy recognizes that Mars offers many varied types of geological terrain which need to be studied before scientists can fully characterize the planet.

The debate that will occur about such missions among scientists, NASA administrators, and members of Congress, will be on how to provide the maximum amount of new, useful scientific information per public dollar spent. There is still a real question whether Congress or the public would support any expenditures to return to Mars for new explorations in the near future. The public can play a part in this debate by expressing their opinions about space exploration to their Congressmen. ☛

Advertise it free in Astro-Mart

● Seven American biological experiments have been successfully launched into orbit aboard the Russian Cosmos 936 satellite. The experiments will examine the effects of spaceflight on the physiology, biochemistry, genetics, longevity and morphology of selected biological specimens including rats and fruit flies.

● NASA has recently received a patent on a wideband receiver for laser communications from five inventor-employees of one of its contractors. The laser signals will help eliminate difficulties with communications between low altitude satellites and ground based stations.

● Total research and development spending in the United States is estimated to reach \$40.8 billion in 1977 — nine percent above the 1976 level of \$37.3 billion. In constant dollars, assuming a six percent rate of inflation, this means an increase of three percent between the two years.

● In the Senate hearing for his confirmation as chief of NASA, nominee Robert A. Frosch testified that manned exploration of Mars was highly improbable before 1990.

Frosch said the tentative timetable called for the possible use of the Space Shuttle to construct a spacelab in the early 1980s which would, in turn, construct and launch the manned spacecraft to Mars. Construction of the manned craft would begin around 1984 or 1985, with a target launch date a few years later.

European Spin-off Benefits NASA

In an unusual twist to an old story, NASA stands to benefit from an industrial innovation. Spin-offs usually come from, rather than go to, the space agency.

This particular industrial spin-off is a European innovation establishing standards for electronic subassemblies used between computers and scientific hardware. The standards, known as CAMAC, have been used in Europe for over six years and have resulted in tremendous cost savings for European university and industrial experimenters.

At Johnson Space Center in Houston, equipment built to CAMAC standards

has been used for six years in scientific experiments flown aboard high altitude balloons. The CAMAC equipment has performed satisfactorily at great cost savings over previously used custom built electronic assemblies.

Savings are envisioned during the 1980s Shuttle era, by which time experimenters from many different American universities and companies will share Shuttle orbiter space with European experimenters.

CAMAC equipment would provide data and control links between Shuttle orbiter computers and experiment hard-

ware in the payload bay. Experimenters would be able to cut experiment costs since major electronics sections would be assembled from a CAMAC subassembly pool. Experiments with common subassemblies would be able to share parts, thereby reducing the cost of reliability.

CAMAC equipment has been shown to be compatible with the "shirt sleeve" environment aboard the orbiter. Marshall Space Flight Center in Huntsville, Ala., is currently examining different CAMAC equipment to determine reliability during the stresses of launch and landing. ☛

Velikovsky Disputed

You may think that the solar system was formed in its present state by the condensation of a gas cloud; Immanuel Velikovsky disagrees. Ever since the 1950 publication of his book, *Worlds in Collision*, he has been the leader of a small but vocal band of people who believe that astronomers and space scientists have been not only publicizing the wrong ideas about recent astronomical history, but also carrying out a massive coverup to hide the true facts.

The central point in Velikovsky's theory is his belief that the records of celestial events found in ancient writing must be taken very seriously.

According to Velikovsky, the past 10,000 years or so have been busy ones for the inner planets. About that long ago, the planet Jupiter ejected a blob of matter that was eventually to become the planet Venus. This ejected material assumed a cometary orbit and went rampaging through the solar system, crossing Earth's orbit many times. When Earth passed through the tail, objects were seen to fall from the sky. The "rains of blood" and the plagues of Egypt are supposedly explained in this way.

Closer approaches of the comet to Earth resulted in still more drastic changes, Velikovsky says. High tides, floods, the parting of the Red Sea, changes in Earth's axis of rotation (causing the sun to stand still in the sky) and even changes in the direction of rotation (causing the sun to rise in the west and set in the east) were observed at these times. As a side effect, Mars was also knocked into an orbit that brought it near Earth. The Venus-Mars interchanges are supposed to be recorded in myths about gods doing battle in the sky.

Velikovsky's followers claim a number of successes that support this bizarre history. Among them are: 1) the high temperature of the planet Venus, which would "logically" result from its origin and wanderings; 2) the radio emissions from Jupiter which they say are related to the recent turmoil there, and 3) the existence of charged particles in interplanetary space (the solar wind), which they say Velikovsky postulated to bring in some sort of "cushioning" effect in the various planetary collisions.

Scientists have taken a somewhat more jaundiced view of these claims. In an address to the American Association for the Advancement of Science,

noted astrophysicist and planetary scientist Carl Sagan pointed out that all the effects explained by Velikovsky can be explained equally well by more conventional models. For example, Venus' high temperature can be attributed to the ordinary greenhouse effect, without recourse to any cataclysm.

The Apollo missions, which brought back rocks from the lunar surface, have also been cited as evidence against Velikovsky. If, as he claimed, the close approach of Venus triggered lunar volcanos a few thousand years ago, it is difficult to explain why the moon rocks have been found to be over three billion years old!

At a more basic level, scientists point out that any force capable of affecting Earth's rotation would certainly destroy everything on it. For example, if the rotation stopped, objects on Earth would still be moving forward at speeds of up to 1,000 m.p.h. Even if events were arranged to give a very gradual deceleration so that no one would be hurt, the heat generated in the slowdown would be enough to boil the oceans. The small forces associated with interplanetary electricity could not begin to change this fact. Therefore, scientists argue, for anyone to survive the event, it would be necessary that the laws of physics were temporarily suspended. Why, they say, should we assume that this happens when we can explain things without it?

James Trefil, physics professor at the University of Virginia, summed up this viewpoint in a recent interview: "If you want to take this sort of historical argument seriously, you have to assume that ancient writers (unlike their modern counterparts) never exaggerated, never lied, and never embellished the truth. To me, this departure from the laws of human nature is even more striking than Velikovsky's departures from the laws of physics. It's much more sensible to talk about a universe in which neither people nor the solar system have changed much in the last 5,000 years." 🐾

Cancer *continued from page 65*

shades which make up an image, the computer displays them in a way that is meaningful to the radiologist.

The current goal is to try to develop a computerized method of separating those women who are in a low risk group (least possibility of developing breast cancer) from those in a high

Chemicals *continued from page 66*

arise when trying to determine exact proportions of elements using photometric measurements for stars many light-years distant from us. In explanation, Pagel suggests there must have been a quick process by which metals formed very early in the history of the galaxy, essentially before any dwarfs formed. Then all stars forming out of the resulting stew would end up with the same enrichment of metals — with the heavy elements created since the earliest days of the galaxy making only minor contributions to later generations. The acronym for this initial outburst of activity is PIE (Prompt Initial Enrichment).

What produces the PIE effect? Of several theories offered, the one outlined by Donald Lynden-Bell of the University of Cambridge seems most accurate. Lynden-Bell pointed out that the extra metals present in these stars formed early in the history of the galaxy could mean either that there really were more metals around then — or that there was less gas among which the metals could be shared. Our standard picture of galaxy formation — in which we imagine that all the gas gathered together, and then stars formed — is not, in his opinion, very plausible. What should really happen is that as soon as a little gas begins to collapse into a galaxy, stars form and begin to distribute heavy elements even while the bulk of the gas is still collapsing.

There is more to this theory: Computer models which allow for star formation at the beginning — while the galaxy was still being assembled — do indeed produce a pattern of enrichment in line with the observations of real G dwarf stars.

However, in response to a question on how sensitive these models are to assumptions about the way individual stars are made out of interstellar gas (let alone how the stars add up to make a galaxy), Pagel affirmed that he is still "not quite sure if we have any idea how stars form at all". Perhaps these forays into the almost-unknown will, by ruling out some ideas about star formation, help us to develop a better understanding of the little-known facts of life about stars themselves. 🐾

risk group (high possibility). If this method becomes feasible, it should reduce the need for repetitive screening mammograms. The new x-ray analyzing system, if successful, may allow separation of women into low, medium and high risk groups, allowing radiologists to concentrate on mammograms from the high risk group. 🐾

Cave ASTROLA

HERE'S WHY NEWTONIAN REFLECTORS
ARE YOUR BEST TELESCOPE VALUES.

American Made — Nationally Available on Extended Payment Terms.



10" ASTROLA DELUXE NEWTONIAN \$975



8" LIGHTWEIGHT DELUXE f/4.5 and
f/14 DUAL CAPABILITY \$625



8" f/7 DELUXE NEWTONIAN \$765

WHY YOU CAN'T HAVE EVERYTHING IN A TELESCOPE ...

Many advertising dollars have been spent by the makers of very compact, folded optical-path telescopes that require a field correction lens along with the reflecting mirror. These short length instruments are highly portable. We agree there's a place for them in some amateur astronomy pursuits, as well as nature study and photography—but we think it's about time to cut through the colorful haze generated by advertising claims, and talk turkey about performance.

When we say "performance," we mean, bluntly, the quality of the image you see or photograph through your telescope—be it binary stars, a moon detail or the rings of Saturn. If you look into the matter, you'll find facts to back up the following:

Aperture for aperture, you can not obtain a folded-path, corrected field telescope, either mass produced or custom designed, that will come close to matching the performance of a well-made conventional Newtonian reflector.

Besides that, the simple Newtonian system, despite its superior image quality, will cost you less. If you haven't seen our catalog you may also be surprised to find that some Astrola 8", 10" and even 12½" reflectors in the shorter focal lengths are remarkably easy to transport and set up in field locations—not for bird-watching, but for serious astronomical observation.

The facts of life are just as real in the optical world as in any other. No one telescope will give you everything—that's why we build 42 different models. You can't have maximum portability with maximum performance. Astrola telescopes are custom built and hand-crafted to give you superior image quality. That's what Cave Optical Company has offered for more than a quarter-century.

Call us if you want to talk about telescopes—we'll make no claims we can't support. The three fine instruments pictured are popular models from our new Silver Anniversary Catalog. Send for yours and learn all about Astrolas before you make important purchase decisions.

ASTROLA NEWTONIAN REFLECTORS

(Selected from more than 40 available models and sizes.)

6"	Student Standard	\$ 295.00
	Student Deluxe	\$ 395.00
	Model "A" Deluxe	\$ 590.00
8"	Lightweight Standard	\$ 395.00
	Lightweight Deluxe	\$ 625.00
	Model "B" Standard	\$ 495.00
	Model "B" Deluxe	\$ 765.00
10"	Model "C" Standard	\$ 625.00
	Model "C" Deluxe	\$ 975.00
	Supercompact Deluxe	\$ 695.00
12½"	Supercompact Deluxe	\$1325.00
	Transportable Deluxe	\$1495.00
	Permanent-Pier	
	Observatory Deluxe	\$2795.00
16"	Permanent-Pier	
	Observatory Deluxe	\$4695.00

Packaging for shipment additional to above prices. All prices f.o.b. Cave plant, Long Beach, Calif.

CAVE TELESCOPE MIRRORS

(Price includes diagonal and aluminizing)

	New	Refiguring
6"	\$ 79.00	\$ 52.00
8"	\$115.00	\$ 68.00
10"	\$197.00	\$110.00
12½"	\$325.00	\$175.00
16"	\$990.00	\$600.00

America's largest selection of oculars, focusers, tubes, finders, cells, spiders, mountings, drives, circles, remote slow motions, and other telescope parts and accessories.

Exclusive distributors of MAG-NUSSON setting circles and CARLE Photo-Visual Focusers and CARLE Camera Adaptations.

SEND \$1.00 (\$2.00 FOREIGN) CURRENCY OR STAMPS FOR YOUR
BEAUTIFUL NEW 30-PAGE 1978 COLOR CATALOG

CAVE OPTICAL COMPANY

4137 E. ANAHEIM STREET
LONG BEACH, CALIFORNIA 90804
Telephone 213-434-2613

Factory showroom open Tuesday through Saturday — 9 A.M. to 5 P.M.

ASTRONOMY

Index to Volume 4, 1976

ASTRONOMY's cumulative Index to Volume 4, 1976 is now available. This subject index covers the months of January through December 1976 (issue Nos. 1 through 12) in an expanded format, making it a valuable addition to your home library!

Index to Volume 4 is available for \$1.25 each,
plus 25¢ per order for postage and handling.

COUNTER SALES

Bookstores, magazine counters, planetariums, museums, libraries and astronomy clubs across the country are finding a new money-making opportunity with ASTRONOMY Magazine.

ASTRONOMY's cover price is \$1.50, but if you place a standing order monthly to purchase five or more copies of each issue for resale you only pay \$1.00 per copy. You make 50¢ on each copy of ASTRONOMY.

Astronomy clubs may take advantage of this too since many members who don't subscribe may want to purchase a single copy at meetings. In addition, if your club gives public lectures or has open house nights you have an excellent opportunity to pad your organization's treasury with extra cash from ASTRONOMY sales.

Orders are accepted from all established places of business, libraries, museums, planetariums and recognized science or astronomy clubs or organizations. Bills are mailed the same day bulk orders are shipped and are payable in 30 days.

Individuals may also act as resale agents but payment must accompany orders until credit is established.

Bulk copies are sold on a nonreturnable basis, so make your first order a conservative one and increase the quantity later when you establish your level of sales. For more information write: **Nancy Faustmann, Bulk Copy Sales**

ASTRONOMY Magazine

411 E. Mason St., 6th Floor Milwaukee, WI 53202

From S&S Optika...Christmas gifts of lasting prestige and satisfaction.



For Celestron Tripods

- Star Chart Holder
- Freight UPS Continental U.S. No Charge

\$5

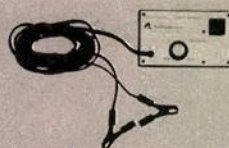
MICRO-FINE LATITUDE ADJUSTOR



- For Celestron Telescopes
- Full Latitude Control at Your Fingertips

- Freight UPS Continental U.S. No Charge

\$19



MICRO-GUIDE

- Output Frequency Continuously Variable from 50-70 Cycles
- 6 Watt Grounded Output Can Drive a Celestron 8
- NASA Spec Circuit Board
- 15' of Battery Cable
- Freight UPS Continental U.S. No Charge

\$29

WEATHERPROOF ACCESSORY CASE



- Carries Six Eyepieces, Diagonal, Telescoper, etc.
- Freight UPS Continental U.S. No Charge

\$14



CHRISTMAS PACKAGE #14B

1. Celestron C-5 Telescope \$625
2. Wedge 39
3. Micro-Fine Latitude Adjustor No Charge
4. Weatherproof Accessory Case No Charge
5. Freight UPS Continental U.S. No Charge
6. Certificate for Special Discounts on Selected Accessories No Charge

TOTAL \$664



CHRISTMAS PACKAGE #11A

1. 3" Unitron Folded Optical Path Refractor \$660
2. 1 1/4" Eyepiece Adaptor No Charge
3. Freight UPS Continental U.S. No Charge
4. Certificate for Special Discounts on Selected Accessories No Charge

TOTAL \$660



CHRISTMAS PACKAGE #10

1. 2" Unitron Altazimuth Refractor with Micrometer Dial Controls (a perfect starter package) \$185
2. Freight UPS Continental U.S. No Charge
3. Certificate for Special Discounts on Selected Accessories No Charge

TOTAL \$185



CHRISTMAS PACKAGE #12B

1. Celestron C-8 Telescope \$785
2. Wedge 39
3. Micro-Fine Latitude Adjustor No Charge
4. Weatherproof Accessory Case No Charge
5. Freight UPS Continental U.S. No Charge
6. Certificate for Special Discounts on Selected Accessories No Charge

TOTAL \$824

CHRISTMAS PACKAGE #15

1. 8" Celestron C-8 Telescope \$785
2. Wedge 39
3. Electronic Digital Readout Circles 299
4. Variable Frequency Drive Corrector (25W) 93
5. Tripod 118
6. Micro-Fine Latitude Adjustor No Charge
7. Weatherproof Accessory Case No Charge
8. Freight UPS Continental U.S. No Charge
9. Certificate for Special Discounts on Selected Accessories No Charge

TOTAL \$1,334

CHRISTMAS PACKAGE #9

For Celestron telescopes. Please specify model.

Miranda Laborec III modified for full aperture photography on Celestron telescopes, including:

- Celestron Photo-Back, Celestron Telescoper and Appropriate Counterweight Set \$252
- Freight UPS Continental U.S. No Charge

TOTAL \$252

ACCESSORY TRAY



- For Celestron Tripods
- Accessory and Stabilizer Tray
- Freight UPS Continental U.S. No Charge

\$20

DIGITAL READOUT SETTING CIRCLES

- Red Display for Preserving Night Vision
- Right Ascension and Declination to $\pm$ One Minute
- 12-Volt DC Operation
- Adaptable to Newtonian Telescopes
- Order Universal Model \$340
- With Celestron 8 Mounting Hardware Add \$ 35
- With Regulator Power Supply for Observatory Use Add \$ 93
- Freight UPS Continental U.S. No Charge

DO-IT-YOURSELF

Name your own package!
Just write down your choice of telescope and accessories, and let us give you our prices.

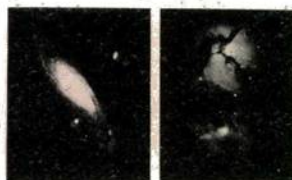
STOCKING STUFFER SPECIAL

Astro Poster
• Full Color
• 18" x 24"

Your Choice of:
☐ Andromeda
☐ Trifid
(Check One)

Free with any of the above integrated packages.
Offer good through December 31, 1977.

FREE!



I am interested in information on:

☐ _____ Telescopes
(Specify Brand)

- ☐ Telescope accessories
- ☐ Camera for telescope use
- ☐ Variable speed drive corrector
- ☐ Digital readout setting circles
- ☐ Other Products _____

(Specify)

- ☐ Check or money order is enclosed.
- ☐ Charge Master Charge card number _____

Colorado residents add 3% sales tax.

Here is my order for:
CHRISTMAS PACKAGE

- ☐ #14B ☐ #15
- ☐ #11A ☐ #9
- ☐ #10 ☐ #12B

ACCESSORIES

- ☐ Variable Frequency Drive Corrector
- ☐ Digital Readout Setting Circles
- ☐ Weatherproof Accessory Case
- ☐ Micro-Fine Latitude Adjustor
- ☐ Accessory Tray
- ☐ Star Chart Holder
- ☐ Focusing Finder
- ☐ Micro-Guide
- ☐ Star Chart

Please clip or copy onto another sheet. Before you buy **anywhere**, just compare.

Name _____

Address _____

City _____ State _____ Zip _____

Telephone (please include) Area Code () _____



S&S Optika, Ltd.

3853 South Broadway
Englewood, Colorado 80110
Phone (303) 789-1089

Celestron International

World's Leading Manufacturer of Quality Telescopes

2835 Columbia St. • Torrance, California 90503 • U.S.A. • Telephone (213) 328-9560

In keeping with our long-standing policy of presenting the finest quality telescopes at the most reasonable prices, instruments that are dependable and trouble-free, and fast reliable service, we present to our friends the following list of authorized dealers. Those interested in more information about Celestron products are invited to contact one of these dealers who can answer your many technical questions and help you determine which Celestron Telescope best suits your needs.

CELESTRON AUTHORIZED DEALERS IN THE U.S. AND CANADA

ALASKA

Stewart's Photo Shop
531 W. 4th Ave.
Anchorage, AK 99501

ARIZONA

Wilson's Camera Sales
145 W. Adams
Phoenix, AZ 85003

CALIFORNIA

Adventures In Fine Photography
155 W. Lincoln
Anaheim, CA 92805

Beach Cities Photo
1822 N. Sepulveda Blvd.
Manhattan Beach, CA 90266

Camera Exchange of Beverly Hills
330 N. Beverly Dr.
Beverly Hills, CA 90210

Century Music
448 S. Winchester
San Jose, CA 95128

Century Precision Cine/Optics
10661 Burbank Blvd.
North Hollywood, CA 91601

De Anza Optical
3737 Moraga, Suite A-102
San Diego, CA 92117

Douglas Telescopes
531 State St.
Santa Barbara, CA 93101

Finley's Camera
48 Peninsula Center
Palos Verdes, CA 90274

(The) Forge
1614 Tapir Circle
Ventura, CA 93003

Frank's Highland Park Camera
5631 N. Figueroa St.
Los Angeles, CA 90042

Henry's Camera
525 W. Eighth St.
Los Angeles, CA 90014

Henzl, Leo C., Jr.
6916 Kings Harbor Dr.
Rancho Palos Verdes, CA 90274

Jacks Camera Exchange
9523 Santa Monica Blvd.
Beverly Hills, CA 90210

Newman's Photo
1150 Hermosa Ave.
Hermosa Beach, CA 90254

Odd Assortment
2057 Salvio St.
Concord, CA 94520

Optech Instruments
266 E. Garvey Ave.
Monterey Park, CA 91754

Optica b/c
4100 MacArthur Blvd.
Oakland, CA 94619

Optron Systems
15840 E. Alta Vista Way
San Jose, CA 95127

Orion Telescope Center
303 Potrero, No. 7
Santa Cruz, CA 95060

Pacific Photo
18120 Brookhurst St.
Fountain Valley, CA 92708

Paul's Photo
23252 S. Hawthorne Blvd.
Torrance, CA 90505

Refractions-Reflections
600 San Pablo Ave.
Albany, CA 94706

Sight Instruments
2620 E. Pacific Coast Hwy.
Long Beach, CA 90804

Sight Instruments
24570 Hawthorne Blvd.
Torrance, CA 90505

COLORADO

Denver Museum
City Park
Denver, CO 80205

S & S Optika Ltd.
3853 S. Broadway
Englewood, CO 80110

FLORIDA

Abba Equipment
511 Northeast 190th St.
Miami, FL 33169

Aberbach's Photo
441 Arthur Godfrey Rd.
Miami Beach, FL 33140

Cole Energy Systems
815 Oranole Rd.
Maitland, FL 32751

Focus Scientific Enterprises
1601 Biscayne Blvd.
Omni International
Miami, FL 33160

ILLINOIS

American Science Center
5700 Northwest Highway
Chicago, IL 60646

Helix Camera
325 W. Huron St.
Chicago, IL 60610

Marshall Field & Co.
111 North State St.
Chicago, IL 60690

Potter Sales & Service
723 Cedar
Sandwich, IL 60548

INDIANA

Lawndale Camera Shop
817 So. Greenriver Rd.
Evansville, IN 47715

IOWA

Jones Camera Supply
1200 East Platt
Maquoketa, IA 52060

KANSAS

Hutchinson Planetarium
1300 N. Plum
Hutchinson, KS 67501

Wolfe's Camera Shop
635 Kansas Ave.
Topeka, KS 66603

MARYLAND

Perma Tone
8638 Loch Raven Blvd.
Towson, MD 21204

Towson Photo Supply
401 Washington Ave.
Towson, MD 21204

MASSACHUSETTS

Astronomics
227 Linwood St.
Lynn, MA 01905

MICHIGAN

Feldman Camera Exchange
300 Oak St.
Wyandotte, MI 48192

University Optics
2122 E. Delhi Rd.
Ann Arbor, MI 48106

MINNESOTA

Duluth Camera Exchange
321 West Superior St.
Duluth, MN 55802

E & W Optical
2420 E. Hennepin Ave.
Minneapolis, MN 55413

MISSOURI

Perpro
4809 Jefferson
Kansas City, MO 64112

MONTANA

AMC Sullivan Photo
107 East Main
Bozeman, MT 59715

NEVADA

Hobby House
2009-11 East Charleston Blvd.
Las Vegas, NV 89104

Univ. of Nevada/Reno
Planetarium Gift Shop
Reno, NV 89557

NEW JERSEY

Dover Photo Supply
25 E. Blackwell St.
Dover, NJ 07801

Edmund Scientific
101 E. Gloucester Pike
Barrington, NJ 08007

Ridgewood Camera
48 E. Ridgewood Ave.
Ridgewood, NJ 07450

Tuthill, Roger
11 Tanglewood Lane
Mountainside, NJ 07092

NEW YORK

Hirsch, Edwin
Lake View Dr.
Tomkins Cove, NY 10986

Johnson's Studio & Camera
3208 Erie Blvd.
De Witt, NY 13214

Main Camera Center
66 Franklin St.
Rochester, NY 14604

Stangert Corp.
94 Long Beach Rd.
Island Park, L.I., NY 11558

Vernoscope
5 Ithaca Rd.
Candor, NY 13743

OHIO

Dodd's Camera
7795 W. Ridgewood Dr.
Parma, OH 44129

OREGON

Conkling, Inc.
4929 N. E. Fremont
Portland, OR 97213

PENNSYLVANIA

Astro-Marts
4801 McKnight Rd.
Pittsburgh, PA 15237

(The) Camera Shop
1420 11th Ave.
Altoona, PA 16601

Carman's
4209 Edgemont Ave.
Brookhaven, PA 19015

TEXAS

Burke Baker Planetarium
5800 Carolyn St.
Hermann Park
Houston, TX 77004

Hidalgo Supply
11246 S. Post Oak Rd.
Suite 308
Houston, TX 77035

Houston Jewelry & Dist. Co.
9633 Westheimer
Houston, TX 77042

Keaton Kolor
3520 N. 6th St.
Abilene, TX 79603

Pampa Photo
1820 N. Hobart
Pampa, TX 79065

Studer's Photo
146 Stribling
San Antonio, TX 78292

Texas Camera
5307 Airport Blvd.
Austin, TX 78765

Texas Nautical
3209 Milam St.
Houston, TX 77006

Total Camera
6128 Westheimer
Houston, TX 77057

Bill Weaver Sporting Goods
3515 W. Vickery
Fort Worth, TX 76107

UTAH

Allen's Camera
36 N. University
Provo, UT 84601

Hansen Planetarium
15 S. State St.
Salt Lake City, UT 84111

WASHINGTON

(The) Camera Shop
1003 Pacific Ave.
Tacoma, WA 98402

Clyed's Camera
1410 4th Ave.
Seattle, WA 98101

B. E. Meyers & Co.
2717 200th Ave. S.E.
Issaquah, WA 98027

WISCONSIN

(The) Camera Center
1700 E. Capitol Dr.
Milwaukee, WI 53211

Wack Electronics
5722 West North Ave.
Milwaukee, WI 53208

CANADA

Brooks Supplies Ltd.
1031 Robson St.
Vancouver, B. C.
Canada V6E 1A9

Edmund Scientific Products
3500 Bathurst St.
Toronto, Ontario
Canada M6C 2C6

Focus Scientific
160 Elgin St.
Place Bell, Ottawa
Ontario, Canada K2P 2C4

Focus Scientific
186 Queen St. West
Toronto, Ontario
Canada M5V1Z1

Lewis Instruments Ltd.
1438 Erin St.
Winnipeg, Manitoba
Canada R3E 2S8

Museum Planetarium Shop
1100 Chestnut St.
Vancouver, B.C., Canada V6J 3J9

Queen Elizabeth Planetarium
Coronation Park
Edmonton, Alberta
Canada T5J 0K1

Tele-Optics
2026 8th Ave., S.E.
Calgary, Alberta
Canada T2E 0N8

STAR DOME

OCTOBER

by

James Mullaney and Henry J. Phillips

By October, we know that we have definitely reached the autumn of the year. Not only has the frequent lingering warmth of September nights given way to the chill of the cooler season, but the stars themselves are changing as the year moves on and draws nearer its end. The summer triangle is going down in the western sky; in the east, the first hints of the bright winter stars are given (Capella, Aldebaran and the Pleiades have already risen), and to the south, we have the star-poor view that is associated with fall. There is a smaller number of bright stars in the autumn constellations than in any other season, including only one of first magnitude: Fomalhaut, in Piscis Austrinus.

Reference is frequently made to the "starless expanses" of the autumn sky, but such a phrase is really quite inaccurate. The stars in the autumn constellations may not be as bright as those of other times of the year, but there are certainly a large number of them arranged in pleasing or easily noticeable patterns. Among the better known of these is a small group of four stars called the water jar, located in the northern part of Aquarius the water carrier. Situated exactly on the celestial equator, the water jar is a Y-shaped configuration that is easily discernible to the naked eye and a charming sight in binoculars.

Aquarius itself is a sprawling con-

stellation — 10th largest in our skies, and second largest of the zodiacal constellations (only Virgo exceeds it in size). The group has always been figured as a boy or man holding (or spilling) a large urn of water. It may have received this designation because the sun passed through it during the rainy season at the time that the constellations were initially identified.

Indeed, many of the surrounding star groups also depict liquid subjects: Delphinus the dolphin, Capricornus the sea-goat (half fish, half goat), Pisces the fishes, Piscis Austrinus the southern fish, Cetus the whale, and the river Eridanus. The autumn sky is probably better known for the presence of this celestial sea than for any of its component star groups.

Aquarius' spilling of the water may have been meant to signify a rain or storm god sending (or pouring) rain down to Earth from the heavens. In ancient Babylon the group's name was Ramman, god of storms. In Greece and Rome, the constellation was associated with (although not named after) Zeus and Jupiter, who began their "careers" as rain gods.

In later Greek times, Aquarius became identified with Ganymede, a youth of Troy who was beloved of Zeus and became cupbearer of the gods. The story is characteristically Greek (for reasons soon apparent), and actually begins some time before Ganymede

himself appears on the scene.

The official cupbearer at the Greek gods' feasts and banquets was Hebe, daughter of Hera. She seems to have always fulfilled her duties efficiently until one unfortunate day at an important festival, when she slipped and fell, splattering some of the more prominent dignitaries with nectar and ambrosia. The guests were outraged, Hebe was embarrassed and disgraced, and a search for a new cupbearer was begun.

One day, as Zeus was roaming over the world searching for beautiful young women to seduce (as was his wont), he happened to see Ganymede, a young prince of Troy, basking in the sun on a hillside. Dumbfounded by Ganymede's beauty, Zeus completely forgot his original intentions; transforming himself into an eagle, he swooped down to Earth, grasped Ganymede in his talons, and carried the young man to the heavens.

After a while, however, Zeus was faced with a dilemma. His wife Hera was extremely jealous of her husband, and kept a close watch on his roving eye. She always inflicted severe punishment on those unlucky maidens with whom Zeus fell in love, and we can imagine her fury upon finding that her affections had this time been displaced not by a nubile girl, but a handsome young man! Zeus' problem, therefore, was how to be able to keep Ganymede

This Star Dome rendering approximates the sky as it appears at about 11:30 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 36.





Map by Adolf Schaller

around without Hera suspecting his real function. He finally hit upon the bright idea of making Ganymede the new cupbearer. Perhaps he decided that Hera could hardly object to being waited on by such a well-endowed youth. Apparently she did not, for Ganymede retained his office as cupbearer, in addition to fulfilling whatever other duties Zeus may have had for him. Incidentally, the story ended happily for Hebe also, because she became the wife of Heracles when that hero was brought to heaven after his death.

Not only is Ganymede present in the stars as Aquarius, but so is the eagle (as which Zeus carried him off) in neighboring Aquila. Ganymede is also the name of one of the four bright moons of the planet Jupiter; the other three also bear names (Io, Europa and Callisto) in memory of some of Zeus' great loves. (Remember that Zeus was identified with Jupiter when the Romans "took over" the Greek gods.)

Early Arabian astronomers, who were forbidden to depict human beings in the stars, called Aquarius a "well bucket", although later, when the restrictions were removed, it once again became a water-pouring man. But whatever Aquarius may have represented to the Arabs, it must have been thought of as a very fortunate grouping, especially when we consider the names of its brightest stars. Alpha Aquarii is called Sadal Melik, which translates as the lucky one of the king; Beta Aquarii is named Sadal Suud, or the luckiest of the lucky.

The stars in the eastern reaches of Aquarius form a "stream" that moves south and terminates at Fomalhaut, located in the mouth of the southern fish. Old atlases therefore frequently show the stream of water spilling from Aquarius' jug being swallowed by the fish beneath the water carrier's feet — a most unnatural pose, because fish don't drink water, although they live in it.

Fomalhaut was one of the four royal stars of ancient Persia. These four ruled and guarded the heavens; there was one for each season (the other three are Regulus, Antares and Aldebaran). These particular four may have been chosen because 5,000 years ago, they marked (more or less) the positions on the ecliptic of the solstice and equinox points. When the sun reaches one of these points in its annual apparent path around the sky, a new season begins.

North of Aquarius is another large constellation: Pegasus, the winged horse, another character well known in Greek mythology (see *Star Dome*, October 1976, for Pegasus' story). Enif, Pegasus' brightest star, is located a short distance northwest of the water jar. The rest of the group extends in

several clearly delineated rows of stars away from the Great Square, Pegasus' (and autumn's) most distinctive group of stars.

When the Great Square appears directly to the south, autumn is in full swing in the northern hemisphere, already giving promise (or threat) of another winter soon to arrive.

Close-Up

Pegasus Region

For all its great size (ranking an impressive seventh in sky area among the 88 recognized constellations), Pegasus is surprisingly poor in telescopic showpieces — a fact reflected in our unusually brief table of selected objects. Indeed, we have had to borrow one specimen (NGC-7662) from neighboring Andromeda to round out this month's fare!

Pegasus' most recognizable feature is the Great Square (actually more of a rectangle), formed by Alpha (α), Beta (β) and Gamma (γ) Pegasi, together with Alpha Andromedae. This last star was once thought of as being shared by both groups, and was given the additional designation of Delta (Δ) Pegasi. However, when the official constellation boundaries were assigned, this star went to Andromeda — which explains why Pegasus today has no star labeled Delta.

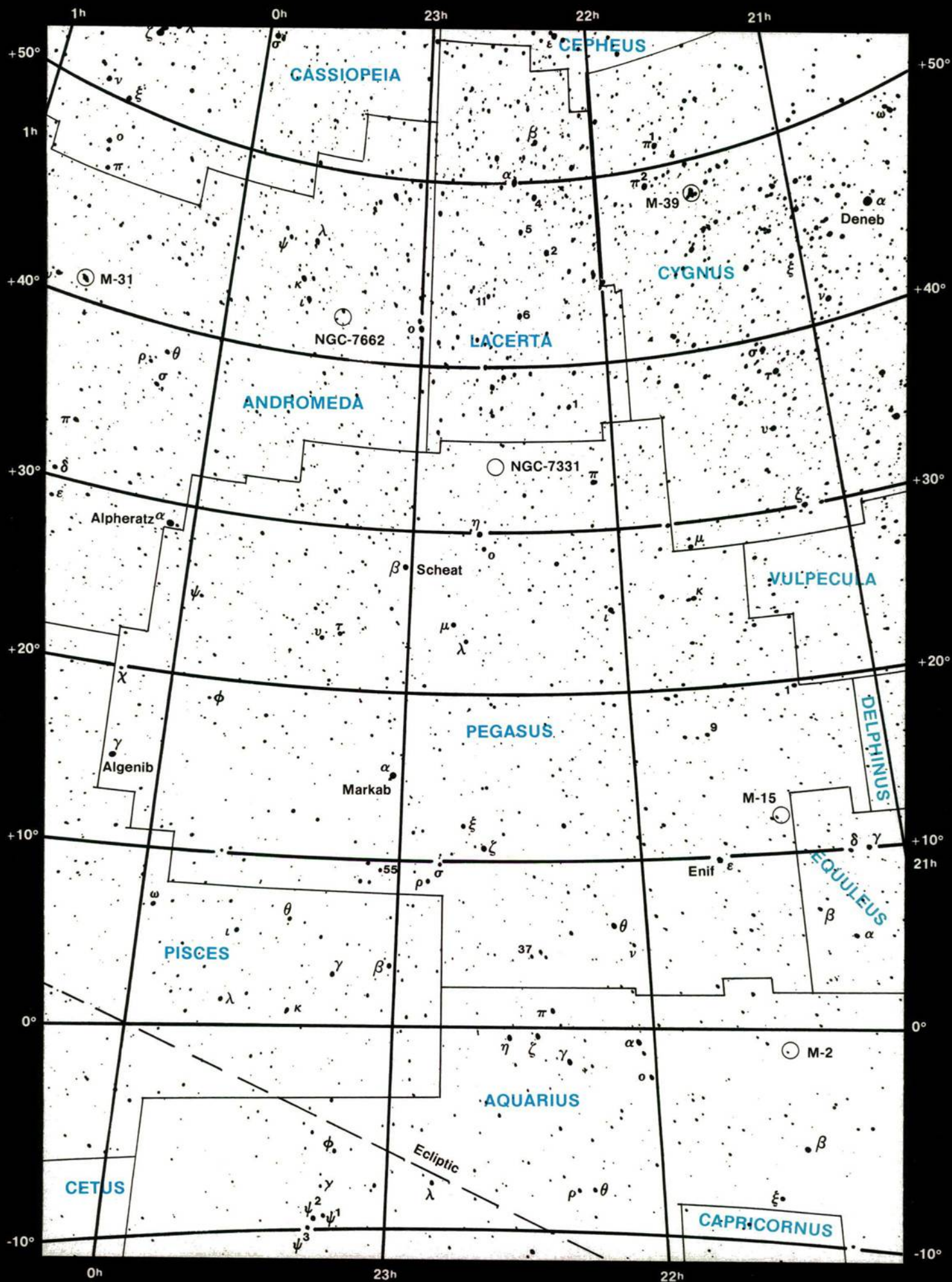
Although at first glance the large space inside the square looks empty to the unaided eye, closer inspection shows it sprinkled with faint stars. The famed German observer Argelander counted 30 naked eye objects within its confines, while Schmidt, observing from the clear skies of Greece, saw no less than 102! How many can you make out from your location on a transparent moonless night?

Among the binocular targets in Pegasus are the globular star cluster M-15 (described in detail below), and the yellow duo Pi (π) 1 and Pi 2 Pegasi. This latter object is an apparent double star having a spread of $1/4$ degree in an east-west direction. Webb called it a "grand pair", and it's a fine sight in 7 to 10 power instruments.

Epsilon (ϵ) Pegasi

We'll begin our telescopic survey of this month's region with a double star that exhibits very unusual behavior. This is Epsilon Pegasi, also known as Enif; it marks Pegasus' nose southwest of the square. It is sometimes referred to as the "Pendulum star", not only because it hangs like a pendulum from the southwest corner of the square, but for other reasons we'll encounter in a moment.

This yellowish orange, K2 supergiant sun shines at magnitude 2.5 and has been suspected of variability by



Photograph by Brad Wallis and Robert Provin/Map by Henry J. Phillips

some observers. Its distance from us is estimated at 780 light-years — rather far for it to shine in our skies as brightly as it does!

Enif has an 8.7 magnitude, blue-violet attendant about 143 seconds of arc away; the scene in a three inch refractor at 45 power is shown in our drawing. There is also a faint 11th magnitude star at 82 seconds, making this object an apparent triple system in medium apertures.

Both Barns and Olcott remarked about the fine color contrast of this system. Smyth saw the tints of these stars (in order of brightness) as bright yellow, violet and blue. Webb recorded them as pale yellow, blue and orange.

Enif would rank as a run-of-the-mill object were it not for its peculiar behavior as seen in the telescope. The story is best told by quoting Webb's detailed account in full: "This object, when near the meridian, will exhibit a

phenomenon, noticed by (John) Herschel — the pendulumlike oscillation of a small star in the same vertical with a large one, when the telescope is swung from side to side. This, he thinks, is due to the longer time required for a fainter light to affect the retina, so that the reversal of motion is first perceived in the brighter objects. I have seen this strikingly in Delta and Zeta Orionis and Delta Herculis."

This effect is stunning and can be seen in the smallest of instruments, even when Enif is some distance off the meridian. Quick, repeated movements of the telescope — enough to shift Enif back and forth across the central third or so of the eyepiece field — give the best result. Like the "Blinking Planetary" nebula in Cygnus (NGC-6826), the Pendulum star is one of the few deep sky objects that "does something" in the telescope! If you haven't seen it yet, you have a very real surprise awaiting you.

M-15

Just four degrees northwest of Enif is a superb globular cluster from Messier's list. This is M-15, easily found quite close to a sixth magnitude star by sweeping with a finder or low power eyepiece. A line from Theta (θ) Pegasi through Enif points directly at it. As Holyoke suggests: "Look for a fly on the nose of Pegasus!"

As is the case with certain other Messier objects, this cluster was actually first noticed by Maraldi, an associate of Messier, in 1745. (At least both names begin with "M"!) It measures over seven minutes in diameter, and its integrated magnitude is given as 6.0. Some sources, however, consider it as bright as 5.2 magnitude, which would make it a naked eye object.

Though smaller and less impressive than M-13, the Hercules cluster, M-15 is nevertheless a grand object and is considered by many to be among the finest of all globulars. Even a four inch glass at 70 to 100 power resolves its outer halo of stars with averted (side) vision, as suggested in our drawing. A six inch reflector at 100 power or more shows glittering pinpoints of light all the way to its compact core. On dark tranquil nights, the view in 10 and 12 inch scopes at 150 to 300 power is simply fantastic!

Webb's impression of M-15 goes as follows: "Bright and resolvable, blazing in center; a glorious object with 9.3 inch mirror. Very fine specimen of a completely insulated cluster. . . . Buffham with nine inch speculum (reflector) finds a dark patch near the middle, with two faint dark 'lanes' or rifts, like those in M-13, unnoticed by (John) Herschel or D'Arrest." Can you confirm any of these features in your telescope on a good night?

The NGC rates M-15 as "remarkable", and Pickering considered it a

Epsilon Pegasi



45x

N

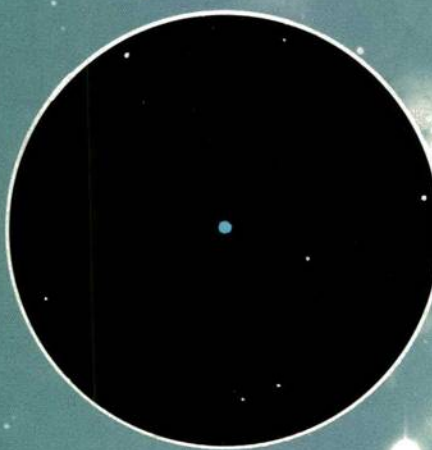
M-15



70x

N

NGC-7662



75x

N

Upper left: Epsilon Pegasi (Enif) is a wide double star with a yellow-orange primary and a much dimmer, bluish companion. The drawing shows Epsilon as seen in a three inch refractor; the field of view is about one degree. Lower left: M-15 is one of the most prominent globular clusters, with a clearly defined core and easily resolvable edges. A four inch reflector at 70 power was used for this drawing; the field of view is 45 minutes of arc. Above: NGC-7662, located in neighboring Andromeda, is a beautiful blue planetary nebula that resembles a glowing blue dot in small instruments. The drawing shows the view through a four inch refractor, with a field of view of 40 minutes of arc. Drawings by James Mullaney.

Selected Objects — Pegasus Region

Object	Type	Mag.	Size/ Sep.	R.A. (1950)	Dec.
PEGASUS					
* M-15	GC	6.0	7'	21 ^h 28 ^m	+11°57'
* ε (Epsilon)	★2	2.5, 8.7	143"	21 ^h 42 ^m	+09°39'
π ^{1,2} (Pi 1 & 2)	★2	4.4, 5.6	15'	22 ^h 07 ^m	+32°56'
37 Pegasi	★2	5.7, 7.0	1"	22 ^h 27 ^m	+04°11'
* NGC-7331	Sp	9.7	10' x 2'	22 ^h 35 ^m	+34°10'
ANDROMEDA					
* NGC-7662	PN	9	32" x 28"	23 ^h 24 ^m	+42°14'

* Detailed in Close-Up

★ 2 = Double Star
PN = Planetary Nebula
GC = Globular Cluster

Sp = Spiral Galaxy
Mag. = Magnitude
Sep. = Separation

"runner-up" candidate for his prestigious roster of the sky's 60 finest objects. Although Barns included it in his classic work, he simply listed it without giving his usual inspired account. A more modern, though conservative, description is provided by Brown: "An eight minute bundle of stars branching out from a central blaze. In the stragglers you may be able to resolve the brighter stars with a six inch reflector."

Observers using a detailed star chart like Becvar's *Skalnate Pleso* atlas will notice that a planetary nebula is shown associated with M-15. This tiny elusive object is only 14th magnitude at best, and is classified as stellar or starlike in form. We have never distinctly seen it visually, even in telescopes as large as a 30 inch refractor!

A very compact x-ray source was discovered inside M-15 by satellite in 1975, and the cluster contains quite a number of short period pulsating variables. Various estimates of its vast distance place it as much as 50,000 light-years from our solar neighborhood.

As M-3 in Canes Venatici heralds the onrush of summer globulars, M-15 in Pegasus and M-2 in Aquarius to the south signal the end of their magnificent display. With the exception of M-79 in Lepus, not until spring will we again have such inspiring objects to gaze upon. Why not check out M-15 now for a last look before the arrival of winter?

NGC-7331

Moving northeast of Enif and M-15, to a point near the Pegasus/Lacerta border, we now venture out of our galaxy to view a distant island universe seldom visited by most observers. This is NGC-7331, forming a triangle with Eta (η) and the Pi duo. A line from Mu (μ) through Eta points to its position. Too small and faint for normal finders, it is best picked up by sweeping with a low power eyepiece on the telescope itself.

NGC-7331 is a 9.7 magnitude spiral measuring some 10 by 2 minutes of arc in size. Discovered by Sir William Herschel, it's number 53 in his class I (bright nebulae). A three inch refractor or four inch reflector working at 45 power will show this object's dim elongated outline on a dark night, floating amid a fairly rich strata of stars. Such a framing is unusual for galaxies, which usually lie in star-poor regions, and this adds greatly to NGC-7331's visual appeal.

Classic observers had virtually nothing to say about this overlooked galaxy, and apparently it gets little attention today as a result. Yet it is brighter than some of Messier's galaxies and easily found in isolated splendor, off the beaten celestial track. Perhaps it has been overshadowed by the great

galaxies in Andromeda and Triangulum (M-31 and M-33) to the east. In any case, it certainly deserves to be better known than it is.

NGC-7331 serves as a guide to one of the most difficult of all deep sky objects, even for experienced observers. This is the famed grouping of five galaxies known as Stephan's Quintet, discovered visually many years ago with a 30 inch reflector in France. It is situated 1/2 degree southwest of NGC-7331; when the latter is placed in the northeast quadrant of a one degree eyepiece field, the ghostly clan of galaxies will lie in the southwest quadrant.

Even though in this way we can be sure of having the cluster in the field, with NGC-7331 as our trusty anchor point, Stephan's Quintet has eluded virtually all who have searched for it. Its brightest unit is 14th magnitude NGC-7320, whose 1950 coordinates are: right ascension 22 hours 34 minutes, declination 33 degrees 41 seconds. The other members of this tight group are much fainter and usually considered a test for a 16 inch telescope. The integrated light of all five objects should make it possible to discern a faint glow in a modern 10 or 12 inch reflector, given excellent transparency and the use of extreme averted vision.

While nearly all of our Star Dome objects can be seen and enjoyed in the smallest of telescopes, some of our well-equipped readers enjoy an occasional test of their observing prowess. Stephan's Quintet offers a challenge second to none for those who care to try it.

At a distance of "only" 10,000,000 light-years, NGC-7331 lies relatively close at hand, compared to the Quintet's vast gulf from us. Even if they're not visible in your telescope, it's still thrilling to know this remote family of galaxies is hiding somewhere in the eyepiece field — swallowed in darkness and unseen by human eyes.

NGC-7662

We conclude our survey of this month's region by crossing over the northern border of Pegasus into neighboring Andromeda. Above the Great Square — a third of the way from Iota (ι) to Omicron ($\omicron$), and just below the sixth magnitude star 13 Andromedae — lies one of the finest planetary nebulae in the sky for smaller instruments. This is NGC-7662 [another of the many finds of Sir William Herschel, which is listed as number 18 in his class IV (planetary nebulae)].

This neat object has a distinct blue disk measuring about 32 by 28 seconds in size, and glows near ninth magnitude. As our drawing with a four inch refractor at 75 power shows, the nebula

is surrounded by several field stars which are useful for critical focusing on the object itself. Even at 30 power on a three or four inch scope, the planetary nebula has a definite nonstellar look to it.

NGC-7662 is transformed from a little blue dot in small instruments to a perforated disk with a dusky center in 8 and 10 inch telescopes at medium magnifications. It has a faint star at its center like most planetaries; this one is somewhere between 12th and 14th magnitudes. This tiny nucleus has been suspected of strange variations over the years, though some attribute this solely to seeing effects. The great observer Barnard made an intensive visual study of this nebula with the 40 inch refractor at Yerkes Observatory, and seemed convinced the variations were real.

NGC-7662 was described as "remarkably bright, slightly elliptical" by Norton, and is listed as a "magnificent object" in the NGC itself. Barns saw it in his 10 inch reflector as "Bright, bluish green, elliptical. Diameter 20 seconds. Variable nucleus and two oval rings."

As usual, the most comprehensive description of this object is that left by Webb: "Small, but very bright. Lassell sees nucleus and 2 oval rings. . . . My 9.3 inch shows a bluish disk with woolly border and suspicion of dark center. Huggins, eight inch; annular, greenish blue."

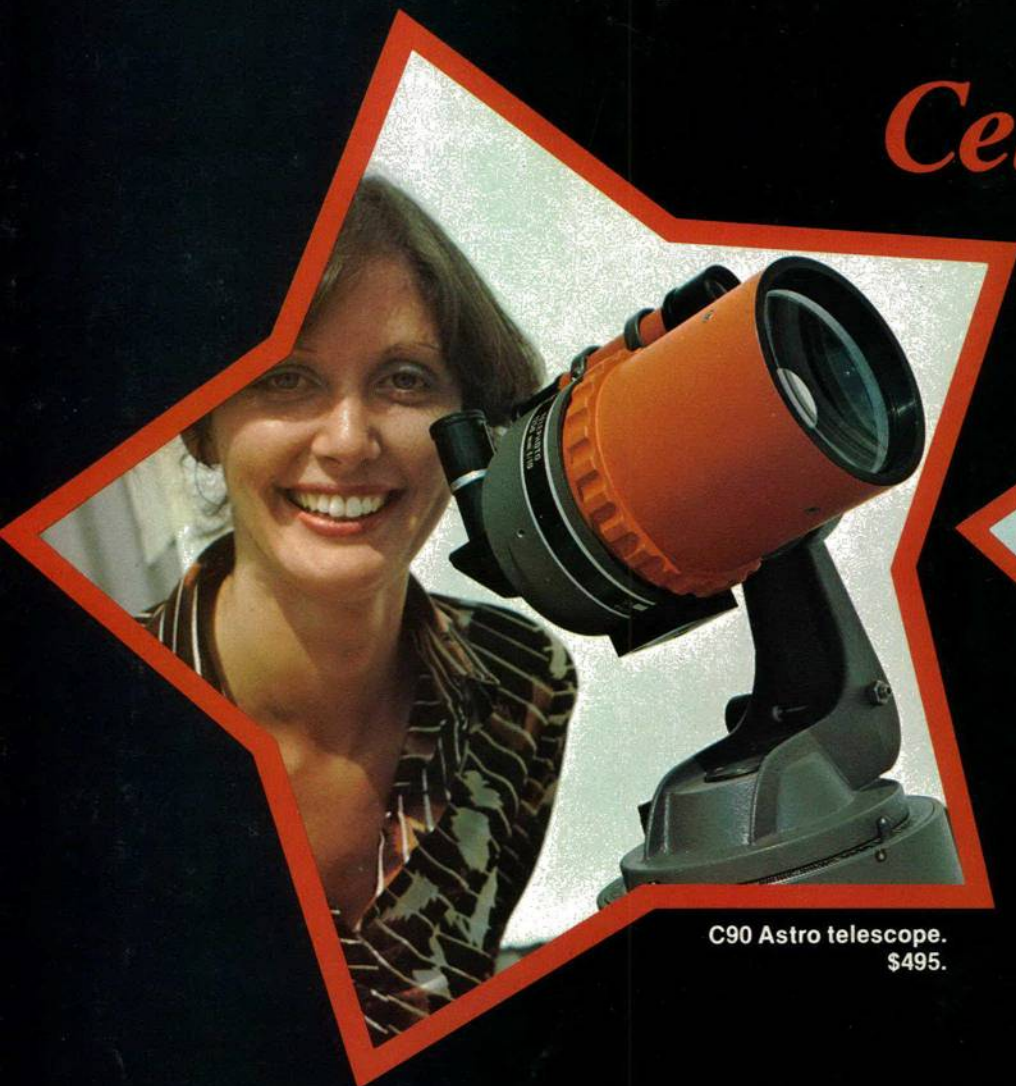
With the exception of a few "show off" members of the class such as the Ring (M-57) and Dumbbell (M-27) nebulae, planetaries take some getting used to compared to other deep sky subjects. One reason is their relatively small apparent sizes — usually measured in seconds of arc, rather than minutes (as for clusters or galaxies). Still, they are comparable to the dimensions of the various planets as seen in the telescope! They can be exciting and rewarding to look at even in small apertures (see "Observing Planetary Nebulae", *ASTRONOMY*, August 1977).

Being bright, easy to find and well placed for fall viewing high on the meridian, NGC-7662 is perfect for cutting your astronomical teeth on. This lovely blue gem beckons our attention from across some 4,000 light-years of interstellar space!

Deep sky wonders — whether spectacular showpieces like M-15 or subdued glories like NGC-7662 — provide the stargazer with an ever-present cosmic perspective of the smallness of man and the vastness of the universe. Yet, do they come nearer to representing the ultimate reality of existence, or do we? As Leonard Cohen so eloquently expressed it in his *Stories of the Street*: "We are so small between the stars, but so large against the sky. . . ."

Celestron 90

Maksutov-Cassegrain Telescope



C90 Astro telescope.
\$495.



C90 Telephoto.
\$245.



C90 Spotting Scope.
\$295.

At last! A quality telescope designed with the beginner in mind and priced so that he can afford it. It's the Celestron 90 and with it you'll be able to study lunar craters, the rings of Saturn, the cloud belts and moons of Jupiter, and scores of nebulae and galaxies. During the day you'll see bees buzzing in flowers 20 feet away, observe birds feeding their young in nests 50 feet away, identify airliners miles away, and much more.

The Celestron 90 has the same quality and features that have made Celestron telescopes world famous:

Portability: The C90 is the ultimate in portability. With its single-fork mounting and drive, it swings down to a compact 7" x 7" x 13" and weighs a mere 8 lbs (approx).

Superb Optics: A full 90mm aperture (3.55 inches) f/11 Maksutov telescope worthy of the Celestron name. The optics are permanently collimated and fully baffled. No other commercially-made Maksutov telescope has the primary mirror as well as the secondary

mirror fully baffled. Its closed-tube design eliminates image-degrading tube currents and keeps the optics free of dust and other contaminants.

Ease of Operation: Place the C90 and its stable mount on a table and it's ready to use. Focus quickly and accurately by rotating the telescope tube. Increase the magnification from 55X to 140X or 200X by simply inserting the barlow lens in the appropriate position. The controls are always at your finger tips. Mount it on the optional equatorial wedge and the built-in tracking system will follow celestial objects indefinitely.

Versatility: The C90 is much more than just a quality astronomical telescope. It's also the ideal telescope for birdwatching, wildlife/nature viewing, or general spotting. The tube may be easily removed from the mount and attached to your photo tripod. Inexpensive adapters quickly couple your 35mm SLR camera to the scope and give you a 20X telephoto lens.

Celestron 90 Specifications

Optics	Maksutov-Cassegrain
Aperture	90mm (3.55")
Focal length	1000mm (40 inches)
Photographic Speed	f/11
Photographic Power	20x
Resolution (Dawes limit)	1.3 arc seconds (120 lines/mm)
Visual Stellar Magnitude Limit	12
Light Grasp	160x (Compared to unaided eye)
Image Scale	1.43"/inch
Illuminated Field	1.5" circle (3" behind cell)
Near Focus (approx.)	15 feet
Secondary Obstruction	1 1/8" (15%)
Finder Scope	5x - 24mm
Slow-Motion Controls	Manual (both axes)
Electric Drive	3 watts, 110V 60Hz
Drive Gear Diameter	4 1/2 inch spur
Setting Circle Diameter	R.A. 6 1/4 inches (Driven) Dec: 4 inches
Color	Orange and Brown
Eyepiece	18mm Kellner, 24.5mm O.D.
Barlow	2.5x
Tube Size	5" Dia. x 8" Long
Weight	3# (approx)
Telescope Size (Swung down)	7" x 7" x 13"
Weight	8# (approx)
Telephoto Case Size	6 1/2" x 8 1/2" x 10 1/2"
Weight	3#
Telescope Case Size	8 1/2" x 8 1/2" x 15"
Weight	3 1/2#

Celestron

Celestron International

2835 Columbia, P.O. Box 3578—AM
Torrance, California 90503
Telephone (213) 328-9560

Deliveries starting Dec., 1977
Send for new color catalog.